Journal of the Royal Society of Arts

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REFLECTION RIDING LECTURE

The Council has gratefully accepted from a Fellow of the Society an endowment which will provide for a periodical lecture on some aspect of landscape amenities or landscape architecture, particularly its practice in any part of the world. The lecture will be known as the Reflection Riding Lecture, and it will commemorate three Americans, Bradford Williams, Vaughan Cornish and Gordon D. Cooper, who influenced the development of the landscape park called Reflection Riding, which is situated on the west slope of Lookout Mountain, Chattanooga, Tennessee. Mr. Williams and Mr. Cooper were both Fellows of the Society, the former having been Honorary Corresponding Member for Boston.

The first Reflection Riding Lecture will be held in the autumn of this year.

EDMUND RICH MEMORIAL LECTURES

It will be remembered that last year a trust fund was established by Mrs. Edmund Rich to provide a biennial lecture on some 'educational or kindred subject' in memory of her late husband, a former Vice-President of the Society and sometime Education Officer to the London County Council. The first Edmund Rich Memorial Lecture was delivered in the session just past. After consultations with Mrs. Rich, the Council has now decided that in the alternate years the funds available under the trust shall be used for a juvenile lecture, which will also commemorate Mr. Rich. The first Edmund Rich Juvenile Lecture will be delivered during the next Christmas holidays.

THE SOCIETY'S CHRISTMAS CARD

As already announced in the last two issues of the *Journal*, this year's Christmas card has been designed by Mr. Edward Bawden, C.B.E., R.A., R.D.I., and its subject is the International Exhibition of 1862, with which the Society was closely concerned.

Full particulars and an illustration of the card are given on the order form included at the back of this issue. Fellows are advised to place their orders as early as possible, since the cards will shortly be ready for distribution.

INDUSTRIAL ART BURSARIES EXHIBITION

As announced in the June issue of the *Journal*, the exhibition of designs submitted in the 1960 Industrial Art Bursaries Competition will be on view at the Belfast College of Art from 4th to 22nd September.

The winning and commended entries in the three technical sections—Domestic Electrical Appliances, Domestic Solid-Fuel-Burning Appliances, and Electric-Light Fittings—will be included in the Domestic Heating and Insulation in-the-Home Exhibition, to be held at the Free Trade Hall, Manchester 3, from 19th to 22nd September.

FACILITIES FOR FELLOWS

Fellows who have joined the Society during the last year, and particularly those from overseas visiting London, may not be aware of the facilities open to them at the Society's House. Two rooms on the ground floor are available for their use: the Library, which has a loan collection as well as a reference section, and the Parlour, which may be used as a reading and writing room or as a meeting place for Fellows and their friends. Light refreshments, such as morning coffee, sandwiches and afternoon tea, can be ordered between 10 a.m. and 5.30 p.m. on weekdays, and until 12 noon on Saturdays.

SOME FOLKLORE AND HISTORY OF DIAMOND

A paper by

S. TOLANSKY, D.Sc., Ph.D., D.I.C., F.R.S.,

Professor of Physics, Royal Holloway College (University of London), and a Member of Council of the Society,

read to the Society on Wednesday, 15th March, with Elkan Simons, Chairman, The Design and Research Centre for the Gold, Silver and Jewellery Industries, in the Chair

THE PAPER

EARLY REFERENCES

Diamond has a surprisingly long and worthy literary history. The very name 'diamond' derives from the early Greek name *adamas*, meaning 'untameable', since certainly before 300 B.C. the ancient Greeks firmly believed that neither by blows nor by fire could the diamond be tamed or subdued, a belief not in fact quite fully justified. Our earliest *written* records of diamond are in fact Biblical, as it is mentioned in no less than six different places in the Revised Version, either specifically as *diamond* or alternatively by its synonym *adamant*. Noteworthy is the fact that even at this early date the diamond is characterized by the very two classifications made of it to-day. For it is mentioned either as a gem-stone or as a very hard engraving tool. The earliest mentions are in Exodus (*c.* 1200 B.C.); there the diamond (Hebrew = *Jahalom*) is twice mentioned as being one of the twelve engraved precious stones set in the breastplate of the High Priest. According to this, each of the stones had engraved on it a Hebrew alphabetical sign, representing one of the Twelve Tribes. Whether or not the Ancients could engrave on a diamond, is a subject to which we will later return.

The later Biblical references, in Jeremiah and Ezekiel (both reliably dated *c.* 600 B.C.) are more to our interest, for here we find attention drawn to that most striking of physical properties of the diamond, its very great hardness, a property which is clearly already recognized at this early date. Jeremiah, attacking the vices of his people, writes 'The sin of Judah is written with a pen of iron and with the point of diamond. It is graven upon the table [i.e., tablet] of their heart and upon the horns of your altar.' (It is made clear incidentally from Exodus 27.2 that the altar horns were covered with brass.) Now two things are noteworthy here. The one is that Jeremiah recognizes that the diamond is a hard material which can engrave on stone and metal. The second is the reference to the 'point' of a diamond. Clearly the scribing is to be done with the tip of the diamond octahedron, precisely as so much later by the scribing rings of the Elizabethan gallants, who

scratched poems on windows, to their lady-loves, with the tip of a diamond octahedron set in a ring.

Ezekiel mentions both adamant and diamond, and it is noteworthy that he is expertly familiar with all the precious materials of his time. In different places he refers to diamond, topaz, beryl, onyx, jasper, sapphire, emerald, carbuncle, agate, flint, coral, amber, crystal, ivory, ebony, silver, gold, iron, tin, lead and brass, and in addition he lists numerous spices and other riches. In Chapter 3, v. 9, he writes 'As an adamant harder than flint have I made thy forehead'. The inference is clear; diamond (adamant) is recognized as being immensely hard.

We have seen then that 2,500 years ago the exceptional hardness of diamond was fully recognized, and it will become apparent that this hardness plays a principal part in affecting the lore which grew up round the diamond.

It has been argued that the learned translators of the Bible from the Hebrew made a mistake in translating *Jahalom*, and that this cannot refer to diamond. The only ground for this criticism is the fact that the gem-stones set in the breast-plate of the High Priest were stated to be engraved with a Hebrew sign, and it was argued that with the primitive techniques available at the time, engraving of a diamond was not possible.

Now this is not a valid criticism of the identification of the name 'diamond'. To begin with, as Sutton has pointed out, numerous diamonds have often been found, which, due to growth or solution mechanisms, show on their surfaces twisted ruts and markings which often can easily resemble an ancient Hebrew alphabetical character. Such a naturally marked diamond could well have been selected and used.

Then again, despite the great hardness of diamond (and nothing is harder), a diamond *can* be engraved upon. For it is the typical characteristic of the diamond crystal (like many other crystals) that some directions are more resistant than others. Diamond engraving is in fact possible with quite primitive means, provided the engraver has immense patience. There are on historical record several diamonds which have been engraved by the old Indian lapidaries, who certainly had only the most primitive methods available. The 'Shah' diamond, now in Moscow, has engraved on it, in Persian, on three separate faces the names and dates of ruler-owners, the earliest being Nizam (1591). It is also on record that the 'Akbar Shah' diamond which was re-cut in 1866 had the names and dates of two royal owners engraved on it, the earlier being Akbar (1618).

If the early Indian workmen, with primitive tools, but with infinite patience, could inscribe both a whole name and a date in the sixteenth century, it is not entirely beyond the bounds of possibility that even two thousand years earlier a single letter might have been engraved on a diamond. There is at least some plausibility in the conjecture. It is incidentally of interest to note that it is almost certain that all ancient diamonds came from India originally.

PLINY

Although it seems that diamond is first mentioned in Greek literature about 300 B.C., our earliest really *detailed* accounts of diamond properties are in the

37th book of the scientific writings of the distinguished Roman naturalist, Pliny the Elder (he died in A.D. 79, overcome by fumes whilst investigating the great volcanic eruption which destroyed Pompeii; he was a true martyr of science). Pliny collected and compiled, and being decidedly uncritical, he gravely reports, in A.D. 77, many strange and fanciful tales, treating them as if factual. His account of the source of diamond is worthy of repetition. It has been stated that this story, reminiscent of a tale in *Sinbad the Sailor*, goes back to the fourth century B.C. The diamonds, writes, Pliny, occur in only one deep inaccessible valley in the East, and they are mined in a curious fashion, for the local natives throw carrion flesh into the valley and to this the diamonds adhere. Mountain eagles then swoop onto the flesh and carry it off to their mountain nests. The diamond gatherers then climb to the nests, and collect the diamonds from the droppings surrounding these nests!

It is possible that such a story was originally deliberately put out and circulated by the owners of the Indian diamond mines to hide the real sources, which were the extensive alluvial deposits centred on the town of Golconda. Yet Sutton has amusingly related that this ancient myth has a real modern parallel. For in South Africa, where the deep-dug mines have heaped around them great masses of waste worked-out ores, it is known locally that the crops of fowls which wander and peck over this land frequently contain small diamonds. The chickens seem to have an eye for the shining pebbles, and a single fowl has been known to have as much as a total of 5 carat weight of small diamond within its crop.

Pliny, like all early writers, lays strong emphasis on the hardness and indestructibility of diamond. It is known that the Romans used diamond for engraving intaglio designs on stones and gems. Pliny records for the first time the notorious legend that if a good quality diamond be placed on an iron anvil and struck by an iron hammer, then the diamond will remain intact but the hammer will shatter. He writes: 'The most valuable thing on earth is diamond, known only to kings, and it is engendered in the finest gold. Six kinds are known and of these the Indian and Arabian are of such unspeakable hardness that when laid on the anvil it gives the blow back with such force as to shatter hammer and anvil to pieces. Its superiority over iron and fire is subdued by goat's blood in which it must be soaked when the blood is fresh and warm. Then only when the hammer is wielded with such force as to break both it and the anvil will it yield. When it yields it falls into such small pieces that they can scarcely be seen.' These curious myths may well have grown as a distortion from genuine observation. For as far back as in the thirteenth century, Ibn Mansur records that if a diamond be pressed in an iron vice, it will penetrate the metal and itself remain unaffected. If this fact was indeed known before Pliny, and it is not unlikely, then such an observation may well have become distorted into the Pliny legend. It must not be forgotten that the very great rarity of diamond would tend to prevent tests being performed to scotch early legends.

Of course experience quickly shows that a violent blow on a diamond does lead to shatter of the diamond. For although diamond is so very hard, it is at the same time very brittle and fractures readily. Indeed jewellers find to their dismay

that the dropping of a diamond, or merely undue gripping of the edges with pliers, can break pieces off it. Its hardness is such that when *slow* steady pressure is applied it bites easily into any metal, no matter how tough. So, naturally, when a diamond shattered on being struck (as is usual) the ancients merely described this as a defective diamond, a conclusion totally unwarranted.

Yet tradition, however wrong it may be, dies hard and it is amusing to note that in recent times unscrupulous diamond dealers have blatantly exploited the old legend, to their advantage. During the latter half of the nineteenth century, when diamonds were being mined in Africa and Australia by the simple credulous diggers, some dealers deliberately spread and fostered the story that a real diamond remains intact when struck on the anvil with a hammer, whilst a pseudo-crystal shatters. Many a credulous digger submitted his precious find to such a dealer who placed the obvious diamond on an iron anvil, and dealing it a vigorous blow with a hammer, shattered the gem into several pieces. With scornful jeers the unscrupulous dealer sent the crestfallen miner packing, without a penny, of course, and once he had departed, carefully collected the broken pieces of gem-stone, still of considerable value, having secured these for nothing by guile and roguery.

It is in Pliny too that we first find in writing the complementary myth: that the 'untameable' can be broken by a blow, provided the diamond is first dipped in the warm fresh blood of a 'billy-goat'. This myth spread to China, where it was modified; Chinese records claim that whilst a blow from an iron hammer fails to 'tame' the diamond, a blow from a ram's horn shatters it completely. Of curious interest in the above quotation from Pliny is his familiarity with diamond dust, later to become so important technically.

CLEAVAGE

It seems to me that these two Pliny myths both hide the fact that the secret of diamond cleavage was known to some and, in accordance with the practice of the times, was being covered up as a mystery art. That a diamond can be cleaved asunder by a fairly light blow on a blade set in the correct (cleavage) direction has been known for a long time. It has been conjectured that this technique was known in early times by the Indian lapidaries, although the evidence is uncertain. The technique was, it seems, familiar to Theophilus, writing in the tenth century A.D. Diamonds occur in Nature largely as one or another of three kinds: the octahedron, which can be visualized as two Egyptian-like pyramids base to base; a variant of the octahedron, which is a triangular plate; and finally the dodecahedron, a somewhat rounded twelve-sided solid, with both the faces and the edges often curved and rounded. In early times the diamonds were used in their natural forms, or possibly cleaved. They were certainly not polished. Cleavage may well have been used to produce a more pleasing symmetry in a badly shaped natural diamond. It is an art which seems to have been lost and re-discovered several times. De Boot, writing about diamond in 1604, mentions its cleavage property, and the distinguished Robert Boyle tells us in 1672 that he was shown by a jeweller how to cleave a diamond. The French traveller and jewel collector, Tavernier, who visited India in 1669 and reported on his study of diamonds there, stated then that the

Indian lapidaries had long been familiar with the art of cleavage. It seems that Wollaston re-discovered diamond cleavage for himself also in 1814, but it was certainly widely known by this time to jewel workers. As regards the goat's blood myth, diamonds often occur having considerable structural weakness, which is often due to inclusion of foreign material during growth. Such a diamond might easily cleave or fracture along cleavage directions merely by being warmed a little, and the temperature of the hot blood may have sufficed in this respect—enough to launch the myth.

Myths about cleavage have also been exploited for gain by the unscrupulous in recent times, again amongst the credulous diggers. Quite often diamonds are dug up which are overall clear, except in some local corner or region where they are cloudy or smoky, due to inclusion. Dealers deliberately fostered the story that smoky areas quickly lead to a cleavage shatter and fracture when such a stone cools down! This is in fact not the case and the purpose of the story was to force down the price to be paid to the digger. A crafty digger on finding such a stone with a smoky corner either kept it warm in his mouth, or buried it in a potato, and rushed it off to the dealer. If the dealer spotted the flaw, the game was up. If not, the digger having obtained his price, beat a rapid retreat, in the firm belief that the stone might explode at any moment. Despite the handling of many millions of diamonds by the big production companies no single diamond explosion has ever been recorded, so in fact the myth itself is exploded!

ANCIENT VIRTUES ATTRIBUTED TO DIAMOND

In the early and late Middle Ages, diamond was worn primarily as a magical amulet, *not* as a decorative gem. Its powers were considered to be great indeed. Because of its natural hardness diamond was believed to endow its wearer with hardihood and manhood. It was thus worn by warriors in battle, on a sword, a dagger, a baldric or a helmet. Many a fine gem was lost on the battlefield. As Leonardus writes in 1502, diamond has enormous virtues. It repels poisons, it disperses fears and is a great defence against sorcery. When worn, it quells quarrels, is a cure for lunacy and a certain remedy against possession by devils. If worn on the left arm then it leads to the conquering of enemies, enables one to tame wild beasts, and is a cure for nightmares. In particular, it makes its wearer courageous and bold in battle.

It is because of its hardness and this endowment of its wearer with hardiness and boldness that the diamond was at first essentially an *amulet* worn by *men*, and it is only much later in its history that it is worn by women, as we shall see shortly.

Diamond was believed to have other miraculous powers, and it is not surprising, all told, that it commanded enormous respect and was only available to the very rich and the mighty. A diamond has the curious power, says Sir John Mandeville, that prince of liars, writing in 1360, of detecting poisons in that it 'sweats' and becomes damp when brought near to poison. In his descriptions of other physical properties, Mandeville clearly confuses a report he has seen about the growing of some crystals from aqueous solution, with the unknown genesis of diamond.

'Diamonds', he writes, 'grow in India, some as big as a bean, some like a hazel nut. They are male and female and from the falling dew they multiply and grow, bringing forth small children.' This is a not unreasonable description of some crystals growing from solution, but of course it has nothing to do with diamond.

Surprisingly enough, it was universally believed for centuries that diamonds had the power of destroying the magnetism of the loadstone. Mandeville and others assert that if a diamond is brought near a sailor's compass needle or any magnet, the magnetism is neutralized, and that the more perfect the diamond the more powerful is the effect. This was just one more of those strange pseudo-scientific fantasies which no one seemed ever to put to the test. The belief persisted until proved false by the distinguished William Gilbert, physician to Queen Elizabeth I, and the founder of terrestrial magnetism. In 1600 Gilbert took a strong loadstone, the most powerful magnet available to him. He surrounded it with no less than 75 diamonds and gravely reports that they had not the slightest effect on it. It is incidentally of interest to note that Gilbert used quite sensitive methods for measuring magnetism, i.e., light magnetized needles floating on water, a detecting system which is surprisingly sensitive.

THE WEARING OF DIAMONDS BY WOMEN

It is stated by Streeter (1879) and has often been repeated after him, that the wearing of diamonds by ladies was first initiated in 1444 by Agnes Sorel, the mistress of Charles VII of France, a woman, it seems, noted for her boldness in dress. This is certainly not the case, for evidence will be adduced below for an appreciably earlier use than this. Two factors should also be recognized. One is that from 1363 in England and from 1380 in Spain, only people of rank were permitted to wear jewels. The second is that arguments will be put forward later in this paper indicating that already by the mid-fourteenth century the art of *polishing* diamond was known. This art converts the uninteresting masculine natural stone amulet into an object of beauty, and it might well be expected that once the diamond became such an object, then the ladies would seek it out for their personal adornment. In fact, as will be indicated, a very close correlation can be found in time between the art of polishing diamond and its adoption by women.

There is certainly definite evidence of the wearing of diamonds by Royal ladies well before 1444. In an inventory, dated 1319, of French Royal jewels for the use of the Queen, there is a description of a collar of gold, studded with diamonds and pearls. Then again in 1369 the Duke of Burgundy is recorded as having, on the occasion of his wedding, presented his mother with a brooch in which four great diamonds were set. Further, in 1396 when Richard II of England married Isabella of France, it is recorded that amongst his presents to her was a collar of diamonds, rubies and pearls. The Duke of York, too, presented Isabella with a diamond brooch. Clearly these are not startling innovations as such, otherwise mention would have been made of the fact.

We see that perhaps a hundred and fifty years before the time of Agnes Sorel, the great ladies were certainly wearing diamonds. Perhaps—and this is a guess—

Agnes Sorel was the first lady of non-Royal blood to wear diamonds; this in itself might have perpetuated the mistaken notion that she was the first woman to wear the diamond.

Up to about 1550 the diamond was still worn in some profusion by Kings and Princes rather than by Queens, but after that date there was a slow change. True, the very largest of diamonds still continued to be worn by men, in sword and in crown, but gradually in personal adornment, by ring, brooch and collar, the ladies began to monopolize the diamond. This went to extremes in the nineteenth century with Mme. Récamier wearing diamonds even on her toes!

THE POLISHING OF DIAMOND

We come now to consider a matter whose origin is certainly now lost in obscurity, the invention of the art of polishing diamond. It has often been stated that diamond polishing was invented in Bruges by Ludwig Berghem, who described the technique in 1476, but this can palpably be demonstrated as incorrect. Berghem in 1476 made a very important contribution undoubtedly, as we shall see later; he certainly did not *invent* the art.

As to the secret of how a diamond can be polished, this is latent in the folk-saying '*Diamond cut diamond*'. It is a matter of astonishment that the techniques used to-day are largely identical with those described by Berghem some 500 years ago and which were undoubtedly used earlier. Indeed, the only significant alteration has been the replacement of the old hand-rotation of the polishing table by modern mechanical rotation. The art of polishing was of course kept highly secret and handed down from father to son. It is based on the following fact: that the diamond crystal has different degrees of hardness in different directions. There are 'hard' directions and 'soft' directions, and which were which was one of the closely guarded secrets of the polishing guilds. Small diamonds, also those of poor quality, are pounded in a metal pestle and mortar. Because of their brittle tendency to fracture and cleavage, they can be pounded down to fine minute sharp grains—*diamond dust*, as it is called. This dust is mixed with olive oil and smeared over a scored and prepared wooden or cast-iron wheel (called a scaife). The wheel is rotated at a high speed of, say, 2,000 revs/min., double if possible, and the diamond particles worked into the surface. The diamond to be polished is now applied to the wheel, using a restricted amount of pressure. Now, amongst the multitude of diamond particles embedded on the wheel surface, are many which present their hardest directions to a diamond face offered to them. If one offers a 'soft' direction, then in due course the diamond is ground away. A facet is made and it takes on a high polish also.

This, or some simplification, seems to have been discovered in India; when, is unknown. The Indians, curiously enough, invented polishing for the express purpose of hiding or removing faults. There was no attempt whatsoever at any organized design. Tavernier, in his 1669 visit to the Golconda diamond fields of India reported that polishing was already a long known art in India, and that the faceted stones he examined were all faulty. Indeed, he says, the more the facets the more faulty was the stone. The facets were distributed quite haphazardly.

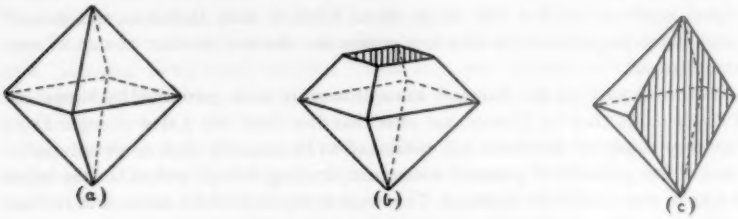


FIGURE 1. *Stages of polishing to achieve the table stone (see explanation below)*

Polishing appeared in Europe in the early fourteenth century and indeed it was at this same time, as we have already seen, that ladies began to wear the jewel. Undoubtedly this latter fact is related to the former. In the first instance the polishing was such as to produce the simple but pleasing shape called the table stone, in the manner shown in Figure 1. Starting with the natural octahedron, Figure 1a, the tip was ground away until the shape, Figure 1b, appeared. The square top, the table (shown hatched in Figure 1b), takes on a high polish, for it so happens that the wearing away of the point in this fashion happens to be the easiest polishing direction of all. Numerous table cuts appear in early examples of jewellery. By the end of the fourteenth century another soft direction had been discovered, a plane from apex to apex, and on being ground this way it leads to the lozenge shape, shown dark in Figure 1c. This became very popular, and numerous old lozenged diamonds are still extant.

There are an appreciable number of written records describing early diamond polished in these two forms and in combinations, since clearly more than one table or lozenge can be produced on a stone. There exist descriptions, made in 1360, of shaped diamonds belonging to the Duke of Anjou. These included (*a*) two small diamonds with three flat-cut four-cornered facets on both sides and (*b*) a diamond in the form of a lozenge. A list made in 1412 of diamonds owned by the Duke of Burgundy includes some table-cuts and one large diamond described as having polished on it four lozenge and four semi-lozenge facets. In an inventory made in 1414 of the jewels of the Duke of Guyenne there was included 'a large pointed diamond, with several lozenge facets'. In 1420 the Duke of Burgundy is described as owning (*a*) small diamonds cut as squares (i.e., tables), (*b*) a good diamond with four lozenges, and (*c*) a diamond polished on several faces.

It is quite clear from all this that long before the time of Berghem (1476) diamonds were already being efficiently polished into simple shapes. Indeed there is also evidence that a diamond-cutters' guild existed in Nürnberg already in 1373 and that by the time of Berghem there were fully developed diamond polishing industries both in the Netherlands and in Paris (where, incidentally, Berghem lived a long while). In a lawsuit recorded in Bruges in 1465, four jewellers, called in to give witness about a disputed gem, are named and described as *diamant-slypers* which, of course, means ***diamond polishers***, and this too is before Berghem. In 1477,

de Metz describes a street in Paris, 'La Courarie', which, he says, is where the diamond cutters live!

What then did Berghem do in 1476? The answer is an important one. He invented for the first time the idea of using a deliberate geometrical design, which brought out the brilliance and fire of the diamond to such an extent, that he has since been regarded as the father of diamond polishing. Berghem clearly understood the optics of the diamond crystal. He probably fully realized, first that a well-polished crystal has a high reflecting surface; secondly, that if light internally strikes a face at an angle exceeding $24\frac{1}{2}°$ it will all be totally reflected. So by careful geometric design practically all the light incident on a crystal could be reflected back, and this of course makes it brilliant. Thirdly, he probably recognized the dispersion, the fact that the light which passes through the crystal comes back to the observer spectrally dispersed, which constitutes the famous coloured 'fire' of the well-cut diamond.

It is perhaps no accident that the optics of the gem should have been first recognized in the Netherlands, for undoubtedly the Netherlanders have historically made vitally important contributions to developments in optics and have indeed a fine feeling for the subject. It is only necessary to recall that in the Netherlands 50 years before Berghem, Jan van Eyck had invented new painting techniques, that 130 years after Berghem, Lipperhey claims the invention of the telescope, and he was followed by a succession of optical authorities such as Snell, Huyghens, Loewenhoek, and so on. Indeed, developments in optics in the Netherlands have gone on until contemporary times and still continue.

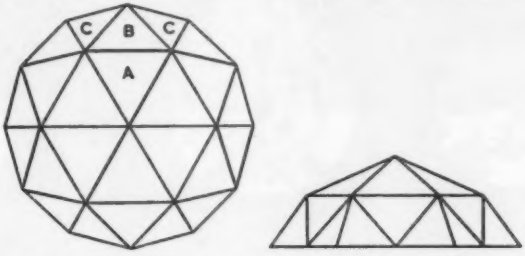


FIGURE 2. *The Rose-cut; upper part (left) and view of side (reproduced from the Geological Museum Handbook of Gemstones, 1958, by permission of the Controller, H.M.S.O.)*

VARIETIES OF CUTS

By 1520 an improved gem-stone design had been developed, the Rose-cut, shown in Figure 2. In 1660 Cardinal Mazarin had a number of diamonds cut in this fashion and he is often wrongly accredited with having invented the design, so much so that such cuts have been wrongly called *Mazarines*. The Rose is symmetrical, has a base and 24 facets, is meant to represent a rose-bud, and is well suited for circular types of crystal. There were several variants of this and each improvement aimed at increasing luminosity and brilliance.

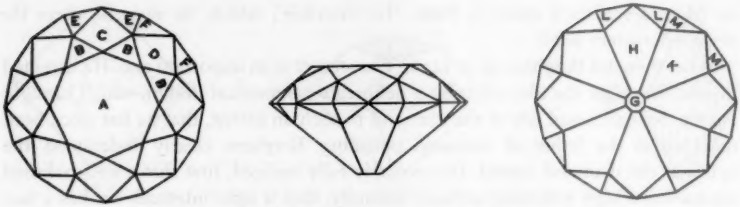


FIGURE 3. *The Brilliant; (left to right) upper part or crown, view of side, and lower part or pavilion (reproduced from the Geological Museum Handbook of Gemstones, 1958, by permission of the Controller, H.M.S.O.)*

Then just towards the end of the seventeenth century Peruzzi invented the Brilliant-cut. Optically this is so superior to all its predecessors that in effect this design (and modifications) remains to-day the basic pattern in which gems are fashioned.

The Brilliant, shown in Figure 3, has a total of 58 facets, and considerable skill is required to fashion one to produce both symmetry and the best fire. A good deal of thought has gone into finding the best proportions, purely from the optical standpoint. There are numerous complex modern variants.

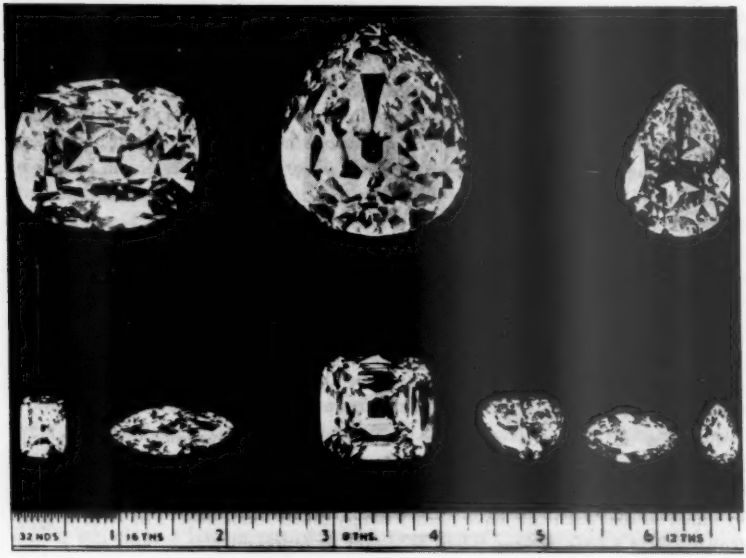


FIGURE 4. *The nine largest gems fashioned from the Cullinan diamond*

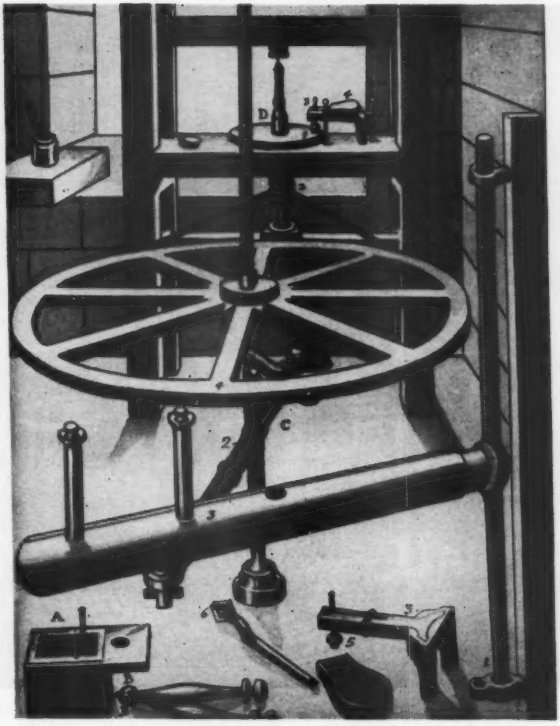


FIGURE 5. *Technical equipment in a diamond-polishing shop, 1676*

It must be realized that natural diamonds are often of irregular shape and to, attempt to make a Rose or Brilliant in all cases might be extremely wasteful. As a result, 'fancy' shapes have been developed to suit stones of different natural outline, the aim always being to exploit the maximum amount of material for the one gem. That these are, in fact, very practical arrangements is illustrated in Figure 4, which shows the nine largest gems (now in the Crown Jewels) fashioned from the very irregular great block of diamond called the Cullinan, of which more later.

THE TECHNIQUE OF POLISHING

It remains an extraordinary and remarkable fact that the technique of diamond polishing used to-day is practically unaltered from that employed 400 years ago. This fact must be virtually unique amongst modern industrial technologies.

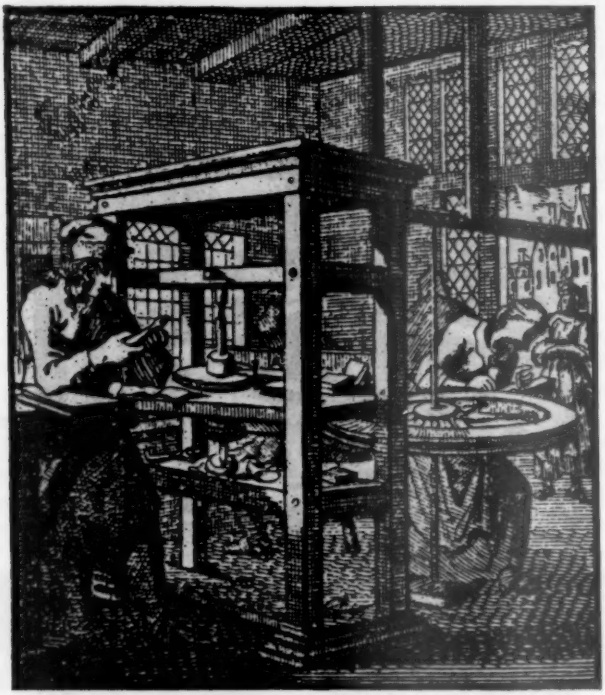


FIGURE 6. *The workshop of a Haarlem diamond polisher*, 1695

Benvenuto Cellini described in 1568 the current method then in use, and his description might well apply to the present, for apart from the use of an electric motor to replace a treadle operated by manpower (often woman power! for the polisher's wife did her share), modern and ancient techniques are virtually identical. Let us look at a vivid print, Figure 5, published by the Frenchman Felibien in 1676, which shows the technical equipment in use in the seventeenth century in a diamond polishing shop. On a shelf, at the left, is a pestle and mortar for pounding diamond splinters into powder. At the bottom left is the cleaver's box, the same as that in use to-day. Near to it are two sticks, B, called to-day *bruting* sticks. Bruting is the pre-roughing of two diamonds by rubbing them against each other and thus rounding off corners, prior to brilliantiering. The grinding wheel, D, near the window, is driven from a large pulley operated by hand. From the dimensions, a rotation speed of over 1,000 revolutions per minute could clearly readily be secured. Most notable is the *dop* and *tang* holder for operating the diamond, shown as 3, 4, resting on the grinding wheel, and shown enlarged as 3, in the bottom right foreground, of which more will be said later.

FIGURE 7. *A diamond polisher at work, c.* 1823

We see further in Figure 6 a print showing the workshop of a diamond polisher, published in the Netherlands, in Haarlem, in 1695, and the technique is identical.

Coming to more recent times, an English book on diamond polishing, written by Mawe in 1823, clearly shows the bruter at work, whilst Figure 7 shows his polisher. Note the striking dop and tang, with the crystal resting on the horizontal grinding wheel. We are already 150 years after Felibien, but the tools are still identical.

Figure 8 shows a *modern* dop and tang, and it might just as well have come out of Felibien's workshop 300 years ago! This extremely simple device which has persisted for centuries is a tripod arrangement. The diamond is fixed either in solder in a cup (on the bottom left) called the *dop*, or nowadays a little sophistication has crept in and clamps to hold the diamond are available—i.e., so-called *mechanical dops*. The dop is held, as of old, on a stalk, a strong yet flexible thick copper wire. This enables it to be tilted in the different directions required for faceting. As in centuries gone by, a mulch of diamond dust and olive oil is applied to a rotating scaife, and as for the rest, it is still a matter of the old skill and patience. The polishing cannot be hurried, for excess of pressure first scores the diamond surface and then blackens it, through local conversion of surface diamond into graphite particles, if there be excess over-heating.

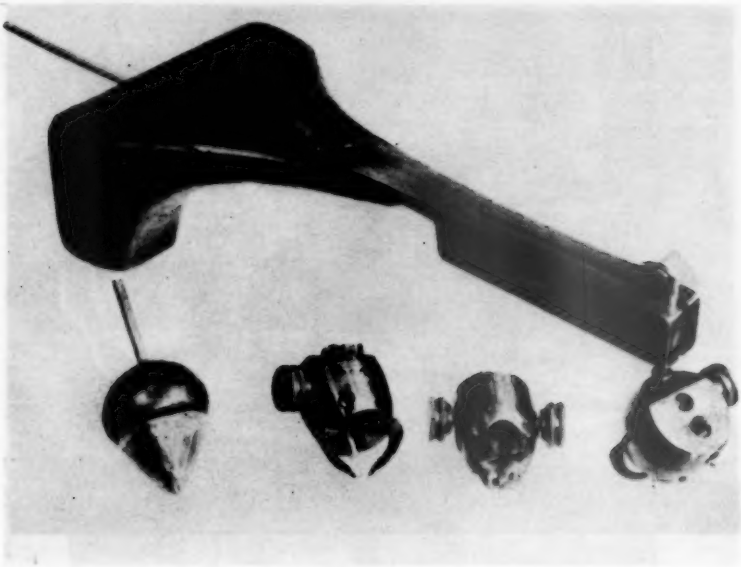


FIGURE 8. *A modern dop and tang used in diamond polishing*

For the manufacture of specially shaped diamond tools elaborate angle-setting machinery is now available, yet skilled craftsmen still prefer the ancient solder dop and tang with its primitive copper stalk.

Modern technologies have contributed only two really significant improvements to the fabrication of diamond. One is the invention of the sawing of diamond. By this means the 'table' is produced by sawing through the stone instead of slowly grinding down the tip. The saw is a thin disc of phosphor-broze metal, $\frac{1}{400}$ in. thick, rotated at high speed, perhaps 6,000 revs/min. With the touch of a roller it is impregnated with a slurry of diamond dust and olive oil. The diamond to be cut rests on the wheel (gravity feed) and it is slowly cut through. A one-carat stone may take two hours, a bigger stone several days. The loss in weight in sawing is surprisingly small, perhaps some 5 per cent. Sawing is now extensively used and has led to a material saving in time and cost in the production of brilliants. It is of course only a preliminary first stage in the ultimate fabrication of the gem.

The second modern technical improvement has not really been widely adopted industrially, being used by very few enlightened operators only. This new advance is the employ of X-rays for accurately locating on the diamond the correct crystal planes, so as to orient the crystal very precisely to secure optimum grinding

conditions. Such a technique offers a genuine saving in labour, but the conservative character of the industry is such that it regards the procedure with suspicious indifference.

It is the very fact that current techniques have remained unchanged for centuries which further encourages operators in their persistent belief that science and technology have very little to offer them in the way of improvements. It is persistently difficult to convince diamond operatives otherwise.

THE CARAT

In the Middle Ages and the period of the Renaissance the really extensively worn gem was not the diamond but the pearl. A glance at any of the classical early portraits of Royal and distinguished personages gives ample evidence of this. Pearl collars, pearl hair decorations and pearl girdles are very common. The well-known portraits of Queen Elizabeth show her dresses to be covered with masses of pearls, certainly thousands. Now it was from the extensive pearl trade of the Orient that the weight measure still used for gems arose. In early times the smallest accepted units of weight were invariably seeds of various types (for example, the barley grain in this country). The ancient pearl dealers of the Orient made the striking observation that the dry seeds of the fruit of the locust-pod tree (*ceratoria siliqua*) are remarkably *uniform* in weight. Irrespective of the age of the tree, and the part of the pod from which the seeds are taken, their weight is surprisingly uniform. Since the tree is widespread in the East and Middle East, this available seed was adopted as the unit of weight for pearls and precious stones. The old Greek name for the plant is *keration*, hence the origin of our word '*carat*', the now universally adopted unit of weight for gem-stones.

The size of the seeds is made clear by Figure 9, which shows five such seeds on a half-crown. When measured with a precision balance these particular five gave the following weights: 0·214, 0·215, 0·215, 0·225, 0·227 gm., i.e., an average of 0·219 with a spread of only $\pm$ 0·006 gm. This is an astonishing uniformity and shows how astute the old oriental jewellers were when they adopted this unit. For, to within their limits of weighing, the seeds are identical.

It has been agreed now to use an international *metric* carat which is precisely 0·200 gm. Subdivision for the pearl is called the *pearl grain*, which is a quarter of a carat. Subdivisions for the diamond are called *points*, which are each $\frac{1}{100}$ carat. Weights are thus given to two decimal places, e.g., 2·51 carats would be described as two carats and fifty-one points. Prices are of course determined by shape and quality as well as by weight. It

FIGURE 9. *Five seeds of the locust pod tree on a half-crown (enlarged)*

has been noted that, crudely, the price of rough diamonds is more or less proportional to the square of the weight. It is for this reason that so much care is devoted to maintaining as large a size as possible in the fabrication of a gem. When a stone is cut in half, the price of the two halves together is a good deal less than the price of the original single gem; the total value may well be halved (i.e., the operation of the square law).

That most diamonds are small will be recognized when it is realized that the carat is in fact quite a small quantity. There are 144 carats to the ounce, yet the small 'point' is a valid unit in costing gems.

In the U.S.A., the main market for the sale of brilliants, a 25-point brilliant of good quality can cost $250, and single carat diamond (100 points) may cost $1,500 when similarly fabricated. Clearly, when fabricated, the change in microweight of only a single point (a mere 2 milligrams) is currently worth no less than 10 to 15 dollars.

It is not possible to estimate the values of large diamonds only by weight, since the price is then determined more by a collectors' market than by any normal financial value. In any case shape, colour and quality play decisive rôles as well as mere weight. In addition to this, romantic history, if any, can easily completely overshadow all other issues.

SOME HISTORIC DIAMONDS

Koh-i-Noor

Perhaps the most celebrated of all diamonds is the 'Koh-i-Noor' (Mountain of Light) which has a very long history indeed. The French expert, Tavernier, examined it in India in 1669 and declared that it was then cut in Rose form and 186 carats in weight. Originally, he said, it was known as the 'Great Mogul' and, although tradition puts its discovery back some four thousand years, it was apparently first heard of in 1304, when it was acquired by the Mogul Emperors. According to Tavernier the original rough weight was 793 carats. There is some evidence that it was shaped to the Rose-cut by the Venetian, Borgio.

It remained, through vicissitudes, with the Mogul dynasty until taken as booty to Persia by Nadir Shah in 1739. The Afghan, Ahmed Shah, later obtained the gem, and it went through his dynasty to Kabul in 1793. In due course it arrived in Lahore in 1813. There it remained until the annexation of the Punjab by the British in 1849, when it was confiscated by the East India Company, and in 1850 this historic gem was presented to Queen Victoria.

It was at this date of irregular shape and poorly cut, and after consultation with experts, including the physicist, Brewster, it was re-cut by an Amsterdam diamond specialist. The re-polish took 38 days and the final weight was 106 carats. It is now among the Crown Jewels.

Hope

Another remarkable story surrounds the famous *blue* diamond called the 'Hope'. The very first mention of the appearance of a blue diamond in Europe was of one

brought back from India in 1642 by Tavernier. This was a unique, irregular diamond weighing no less than 112 carats, and it was bought by Louis XIV in 1668. It was then cut in a triangular faceted shape weighing 67 carats, and it was noted for its unusual and unique violet colour. In 1792 it disappeared from the French Regalia during the Revolution. Then in 1830 there appeared mysteriously (with no explanation of its origin) a beautiful cut stone of colour identical with that of the missing blue stone, but of weight only 44 carats, and of different shape. This became the property of a Mr. Hope. There is little doubt that this was a re-cut of the famous missing Tavernier blue, especially since in 1874 there appeared in a sale of the Duke of Brunswick's gems a much smaller diamond, yet of absolutely identical colour. It was clear that this smaller blue and the 'Hope' together made up the missing original Tavernier stone stolen from the French Regalia. It had been cut and refashioned.

The 'Hope' is the largest coloured diamond known and has a tradition of bringing ill-luck to its owners.

Pitt

The magnificent 'Pitt' brilliant is a further stone with a fantastic history attached to it. This was found in India in 1701, weighing originally 410 carats. After many adventures, involving several murders, it was acquired by William Pitt, Governor of Fort St. George, for £20,000. He had it re-cut into a perfect brilliant weighing 136 carats, and it is recorded that this work took two years. The off-cuts alone fetched many thousand of pounds. Pitt then sold the brilliant in 1717 to the Regent of France for the then very great figure of £135,000, a commission of experienced French jewellers having assessed its real value as £480,000.

Together with Tavernier's blue diamond (later the 'Hope'), the 'Pitt' too disappeared in 1792 from the French Royal Regalia, but this exceptional brilliant was actually restored to the French State. It was later put in pawn by the French Government, with a merchant in Berlin, but subsequently redeemed and finally mounted in the sword hilt of Napoleon I. It is now in the Louvre in Paris.

Cullinan

Unique in size and in a class by itself is the great 'Cullinan' diamond, discovered in the Transvaal in 1905. Four inches long, the rough original stone weighed the colossal amount of 3,106 carats (over 1⅓ lb.). It is shown in Figure 10 with part of a foot rule alongside to give the scale. It was decided, after careful analysis, that this diamond could best be fabricated by first cleaving it into three pieces, which was an operation undertaken by the craftsman with great trepidation, on account of the possible danger of shattering so large and valuable a crystal. Much care went into the final fabrication, and ultimately the pieces were fashioned into four very large gems, plus five of medium sizes and ninety-six small brilliants. The finished weights of the four major gems (Figure 4) are 516, 309, 92 and 62 carats. The Cullinan gems are now part of the Crown Jewels of the British Royal Regalia.

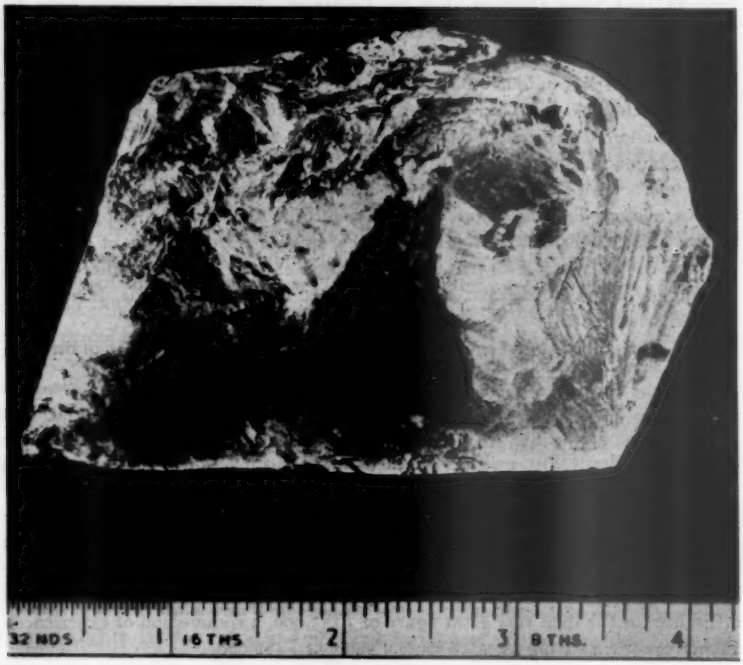


FIGURE 10. *The Cullinan diamond in its original state*

THE RARITY OF DIAMOND

Strangely enough, although diamond was once the rarest of gems, this is not true to-day. The vast mining operations in South Africa are such that no less than five tons of diamond are now produced each year, of which one ton is of gem quality and the other four tons are used for industrial purposes, as a hard technological material. The immense development of mining facilities has made what is the most expensive of gems at the same time the most abundant. Yet in the ores, diamond is present only to the extent of *one part in ten millions* even in the very rich ores. Indeed, over a hundred million tons are sorted each year for the required output. A cubic yard of ore must be searched to produce half a carat of diamond.

Originally the diamonds were sorted by hand picking, but in 1897 Kirsten discovered that if the crushed ore containing diamond is washed over tables coated with grease, then the diamonds adhere to the grease whilst the rest of the material does not. This considerably simplified and speeded up the mining operations. Recently, electrostatic separation has been devised, based on the very low electrical conductivity of most diamonds.

Since a ton of diamond corresponds to about five million carats, and even if the

average diamond used in jewellery is a carat in size (it is probably less), it is clear that the supply can cope with the annual adornment of many millions of people, and of course, nowadays in Europe and the U.S.A. most ladies secure some diamond jewellery at least.

It is interesting to note that within recent years there has been a very great change in the situation so far as the number of *large* diamonds available is concerned. Large Indian historical stones were a rarity indeed. Apart from those already described, there exist the Orlov (200 cts.), Sancy (55 cts.), Shah (95 cts.), Akbar Shah (119 cts.), Nassak (89 cts.), Taj-E-Mah (146 cts.), Pigott (49 cts.), Eugénie (51 cts.), Florentine (136 cts.). Tavernier reported seeing a large table stone (242 cts.), but it has vanished.

It is apparent that anything exceeding some 50 carats was, in the past, of sufficient rarity to acquire a personal name and to acquire a personal history too. Yet in South Africa since the beginning of this century there have been mined a surprising number of very large diamonds. An analysis reported by Williams in 1932 merely of the very large South African diamonds found in the course of some 50 years, makes surprising reading indeed in view of past history. In this list there are three diamonds of over 1,000 carats (including the fabulous Cullinan), 11 diamonds of over 500 carats, 16 weighing more than 400 carats, 34 of over 300 carats, 160 weighing more than 200 carats and actually 1,600 diamonds weighing more than 100 carats each! This is astonishing when compared with the mere handful, say 20, of mostly much smaller diamonds, regarded as the historical giants of the India diamond fields, which have been worked for a thousand years at least. And it should be noticed that Indian diamond mining was on a considerable scale if Tavernier is to be accepted, and there is no reason to doubt him. Tavernier records that in his time the Golconda fields still gave employment to no less than 60,000 workers. True, they merely scratched the earth with primitive wooden tools, but they had been doing this in formidable numbers for a formidable number of years.

The once rare diamond is now the commonest of gem-stones yet still the costliest and most sought after. An economic contradiction perhaps; yet not so, for diamonds are bought by men to decorate their ladies and this is an impulse which defies the mere laws of economics.

LITERATURE

1. Holy Bible, Revised Version: Book of Exodus, Book of Jeremiah, Book of Ezekiel.
2. Pliny, *Natural History*, Bk. 37 (A.D. 77).
3. E. W. Streeter, *Precious Stones and Gems*, London, Chapman and Hall, 1879.
4. *Encyclopædia Britannica*, 10th Edition, London, 1900.
5. A. Fersmann and V. Goldschmidt, *Der Diamant*, Heidelberg, Winter, 1911.
6. J. R. Sutton, *Diamond*, London, Murley, 1928.
7. A. F. Williams, *Genesis of the Diamond*, London, Benn, 1932.
8. L. J. Spencer, *Key to Precious Stones*, London, Blackie, 1936.
9. J. R. McCarthy, *Fire in the Earth*, London, Hale, 1946.
10. J. Evans, *History of Jewellery*, London, Faber, 1953.
11. P. Grodzinski, *Diamond Technology*, London, N.A.G. Press, 1953.
12. G. F. Herbert-Smith, *Gem-stones*, London, Methuen, 1958.

DISCUSSION

THE CHAIRMAN: There is one quesstion I should like to put. I understand that diamonds are highly phosphorescent. Would you say the phosphorescence varies with the size and the particular cutting of the diamond?

THE LECTURER: Not all diamonds are phosphorescent. The phosphorescence is due to metal impurity. However, it varies enormously. These impurities are often silicon or aluminium. Traces of aluminium occur even in the best of gem stones.

MISS IRIS HOPKINS, F.G.A.: Has the Lecturer ever come across a cuttable cube?

THE LECTURER: There is one on the table.

MR. A. POWIS BALE: The Lecturer has emphasized the hardness of diamond. I am rather more interested in industrial diamonds, so called bort. I would like him to give me, as an engineer, some estimate of the relative hardness of ordinary diamond, industrial diamond and tungsten carbide.

THE LECTURER: I have spent many years studying this hardness problem. It is very difficult to give an actual figure, because if you want to know the hardness of something you measure it in relation to something else.

One of the tests of hardness is to indent an object by means of something harder. You can then say that the indentation is a measure of the hardness. The problem arises as to what to use to indent a diamind with in order to measure its hardness. However, the hardness of diamond varies in different crystallographic directions. You can find harder directions in the diamond which can actually permit of production of indentations in the softer directions. If you take the figures for what is called Vickers indentation, the hardness of steel may be some 500; the hardness of a very hard carbide is about 2,000; the hardness of a diamond is perhaps 8,000–10,000. That is the hardness of the softer direction of the diamond. As to what the harder direction is, we have no guide to tell us. It is perhaps only 25 per cent to 30 per cent more at a guess.

MR. P. K. SHAHANI: Could the lecturer tell us something about the synthetic diamond?

THE LECTURER: I do not know how fair it is to those in the audience who are not technologists to answer this in detail. However, synthetic diamond is manufactured in this way. A diamond is a crystallized form of carbon and it had been hoped for many years to produce synthetic diamonds by attempting to crystallize carbon at very high pressure. It is considered that diamonds emerge from very low down in the earth, at a depth may be of about 240 miles. The pressure and temperature there are such as to turn carbon graphite into diamond. The problem is this: can one produce such temperature and pressure conditions artificially? The answer is yes. There has been some controversy as to who were the first to do it. The Americans were certainly the first to do it on a large scale in 1955. They used high pressure equipment (order of 100,000 atmospheres) at 2,000 degrees. They found that, when the pressure was applied at high temperature to graphite in contact with such metals as tungsten or nickel, then at the interfaces a metallic carbide was formed and encrusted on the fine carbide were micro-crystals, which were in fact impure diamonds. Over a million carats a year are being produced in America, but they are all very tiny.

We have heard in the last few weeks that the Americans have made much larger diamonds, but I have not seen any. They say that these crack very easily and are full of faults. I think the time *will* come when we shall be able to make gem quality diamonds—not that I think this will affect the value of a natural diamond at all. There exists an interesting parallel. Some years ago it was discovered how to make rubies artificially. These rubies were genuine, and were as much rubies as the

natural ones; yet one can distinguish between them with a microscope. The result is that the synthetic ruby had no effect on the market price of the natural one. The buyer has a horror of the 'synthetic' because, he says, they are not 'natural'. The same happened with pearls. You can make cultured pearls by inserting a piece of mother-of-pearl inside an oyster—the oyster will then produce a genuine pearl, a pearl just as real as a 'natural' one from another oyster. However, it is treated as unnatural because it is 'cultured'. Optically, when you drill a pearl, you can tell the difference between the real and the cultured, since you can see the seed on which the cultured pearl grew. The cultured pearl has not influenced the price of the real pearl.

I can distinguish between real and synthetic diamonds, and I am going to predict that if large clear synthetic diamonds are ultimately made, they will not seriously affect the price of the natural gem diamond, which is used decoratively; but they certainly will influence the price of industrial diamonds.

MR. J. A. WHITE: I believe I have read about boron nitride, which is claimed to be harder than diamond. If this is so, why has it not been used in testing?

THE LECTURER: I know the claim has been made, but it has not really been fully substantiated.

MR. L. VAN AMERINGEN, F.G.A.: Professor Tolansky mentioned some new techniques in diamond polishing being used in America. Can he give us any details?

THE LECTURER: The newer techniques help to orient the diamond for working in the truly easy directions. There are directions which the traditional diamond polisher calls 'easy' and 'hard'. The scientist says those directions are very critical; the diamond polisher says they are not. However, he is in practice not on a really critical direction. If he were right on the mark he would probably have a 20 per cent saving in labour. He is always more or less off.

Some American polishing firms have listened to the scientist, and have installed X-ray equipment for orienting. Clearly there must be a sufficient gain for the American diamond polisher to buy this expensive equipment. The diamond is set up and illuminated by X-rays and the correct setting can be found in a matter of minutes. The X-rays show a crystal spot pattern. The polisher adjusts it until he obtains the right setting. Correct orientation to within a degree or so matters in terms of time consumed in polishing, which is a slow business.

MISS HOPKINS: I understand that diamonds have recently been made at Teddington. Has Professor Tolansky seen any of them, and if so how did they compare with the American ones?

THE LECTURER: I have not seen any, although the Director informs me that they are on the usual small scale; being effectively grit-size. The diamonds are just the equivalent in size of crushed grit.

THE CHAIRMAN: How quickly this afternoon has gone; I could have continued listening to Professor Tolansky for a longer time.

I should just like to say one thing; after listening to him, I do agree that diamonds are indeed a girl's best friend!

I ask you to join me in a hearty vote of thanks to Professor Tolansky.

The vote of thanks to the Lecturer was carried with acclamation.

THE LECTURER: Thank you. I am only sorry that I have not had time to go into the aspect of diamond which really interests me, namely the scientific and technological aspect. What I have talked about was the lighter historical aspect.

Mr. Oswald P. Milne having proposed a vote of thanks to the Chairman, which was carried with acclamation, the meeting then ended.

THE NUTRITIONAL PHYSIOLOGY OF LIVESTOCK UNDER NATURAL CONDITIONS

The Fernhurst Lecture by

K. L. BLAXTER, D.Sc., Ph.D., B.Sc.(Agric.), N.D.A.,

of the Hannah Dairy Research Institute, delivered to the Society on Wednesday, 19th April, 1961, with the Rt. Honble. Lord Netherthorpe, Past President, National Farmers' Union, and a Member of Council of the Society, in the Chair

THE CHAIRMAN: I think it is fitting that we should, on this occasion, remind ourselves of the origin of the Fernhurst Lecture, and of its terms of reference. I quote from the Society's *Journal* for 31st December, 1948: 'In view of the long and important association of the Royal Society of Arts with the development of agriculture, Plant Protection Limited have offered to endow an annual lecture to be delivered before the Society on the applications of science to agriculture. The Council have accepted this generous offer and it is expected that the first of these lectures, to be known as the Fernhurst Lecture, will be included in the programme for the 1949–1950 Session.'

It was a very far-sighted and magnanimous gesture on the part of Plant Protection to initiate this provision, and on this occasion we are particularly happy to welcome Dr. Kenneth Blaxter. He is a phenomenal man: one of the few Englishmen who works in Scotland! Amongst his hobbies are painting in oils, and believing, as we do, that the environmental factor contributes to the best endeavour we have sited them [*pointing to the oil paintings around the room*] in this room for inspiration!

Dr. Blaxter is devoting his great acumen to the study of animal nutrition and has done a tremendous lot of work that the agricultural industry has profited and will profit from. We are looking forward immensely, Dr. Blaxter, to the privilege of hearing you, and we should like to take this opportunity—and I am sure the company present will be with me in this—of congratulating you on being the recipient of the Thomas Baxter Prize in 1960, which is for outstanding service to the dairying industry in this country.

The following lecture, which was illustrated with lantern slides, was then delivered.

THE LECTURE

When farmers meet, one topic of conversation is inevitable: the weather. This lecture deals with this conversational topic in the particular context of the effect of weather on the well-being of stock. The natural conditions to be considered are the range of outdoor climatic conditions in Britain, but indoor climates are considered also. Sheep and cattle are dealt with in more detail than are pigs, since pigs are not usually subjected to the undiluted ferocity of our British climate.

Meteorological statistics provide a wealth of information about the weather

in different parts of Britain, and these statistics are usually summarized and published in terms of averages for a month or for a season. This average information is less valuable in assessing the potential effects of weather on stock than is the frequency with which different types of weather, and particularly of extreme weathers, occur. To obtain this type of information, recourse has to be made to original records, and Table I summarizes an analysis of the weather at Kew in England and at Eskdalemuir in West Scotland during a ten-year period from 1939-48. The Table shows that for two weeks of the year at Kew and for five weeks at Eskdalemuir the average temperature is below freezing point, and that for eleven days only does the average temperature at Kew rise to over 20°C. It never does this in Scotland! Both Kew and Eskdalemuir have nineteen weeks with very little or no wind. Kew has three days in each year of serious gale, while Eskdalemuir has over three weeks. A further analysis in Table II shows that at Kew the chance of a high wind is equally great at all temperatures up to 15°C., but that warm days tend to be still. At Eskdalemuir high winds are more likely to occur at cool temperatures and less likely to occur at extremes. Very cold weather and high winds are rare combinations.

TABLE I

AVERAGE WEATHER CONDITIONS AT KEW AND AT ESKDALEMUIR: 10-YEAR PERIOD, 1939-48

Observatory	*Number of days per year with average temperature of*					
	Degrees Centigrade					
	Below 0	0–5	5–10	10–15	15–20	*Over* 20
Kew	13	56	99	107	79	11
Eskdalemuir ...	34	88	120	105	18	Nil

Observatory	*Number of days per year with average wind speed of metres/second*					
	Still	0–3	3–6	6–9	9–12	*Over* 12
Kew	8	135	180	47	3	Nil
Eskdalemuir ...	24	135	143	63	21	3

TABLE II

CHANCES OF HIGH WINDS (>6 METRES/SECOND) OCCURRING UNDER DIFFERENT TEMPERATURE CONDITIONS: CHANCES IN 100

	All temps.	*Below* 0	0–5	5–10	10–15	15–20
Kew	14	17	14	20	14	5
Eskdalemuir ...	24	13	26	39	13	5

It has been established by both practical trials and long-term experiments in climatic rooms that milking cows, the most sensitive of all adult stock to heat, suffer no diminution in productivity until environmental temperature is raised to above 25°C. Even then small air movements help them to maintain a thermal balance. Furthermore, experiments have shown that even if the environmental temperature has a large diurnal variation, a mean daily air temperature of 25°C. is still a reasonable estimate of the temperature above which milk production in cows may fall. There are but four days in ten years at Kew when average daily temperature exceeds 25°C., and none at Eskdalemuir. Any decline in the productivity of cows in Britain during the summer is certainly not primarily the result of a direct stress of heat but rather to an indirect one when drought and hot weather reduce the food available. It follows that in any assessment of the effect of our climate on animal productivity we are almost entirely concerned with its coldness. There is every evidence that stock do suffer from cold. Figures 1 and 2 give practical examples of the reaction of sheep and of cattle to cold outdoor conditions.

In attempting to analyse the effects on stock of those attributes of climate we ourselves associate with a feeling of cold and general unpleasantness, I will first deal with attributes of the climatic environment to which the animal reacts. Secondly, I will discuss the general physiological mechanisms the animal employs in combating cold; thirdly, the precise estimation of the loss in productivity which occurs in the cold and, finally, deal with some of the more practical nutritional and economic implications of these findings.

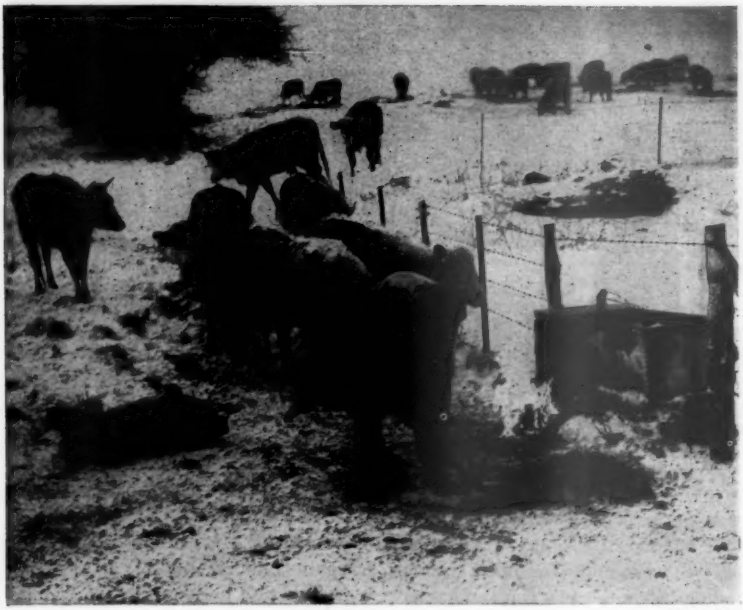
Animals lose heat by convection, conduction and by radiation, which together are called the sensible loss of heat. They also lose heat by vaporizing water from the skin and respiratory passages. In the cold the amounts of heat lost by vaporizing water are small compared with losses by sensible means. The physical laws which govern convection show that the heat lost depends on the gradient of temperature between the air and the surface of the animal and the velocity with which the air moves over the animal. Wind increases the convective loss of heat, not in proportion to its speed but in proportion to the square root of its speed. Relatively still air, such as the air in enclosed buildings, therefore causes a smaller loss of convective

[Alex C. Cowper

FIGURE 1. *The climatic conditions under which sheep are kept. A blizzard is blowing but food is available*

heat than air out-of-doors, which is rarely still. Approximate corrections can be made to air temperature measurements for different wind speeds, to bring them to equivalent 'still air' temperatures. An approximation is involved, since the more heat the body produces the higher will be its surface temperature and the greater will be the heat it loses by convection and the greater the chilling effect of a wind.

Heat losses by long-wave infra-red radiation are determined by the temperature of the surface of the animal and the 'surfaces' which surround it. Indoors these surfaces are walls, floor and ceiling. Outdoors they are the ground and the sky. Ground surface temperature is usually very close to air temperature, but the radiant temperature of the sky can be very much lower than air temperature. If there is low cloud and the air is very humid then the radiant temperature of the sky may be the same as air temperature. Clear dry weather means radiant temperature is as much as 10°C. below air temperature. Under extreme arctic conditions the radiant temperature can be 30°C. below air temperatures which themselves are about −30°C.! Short-wave solar radiation adds heat to the animal. The gains in winter are on average small, but for short periods of time they provide a very real amelioration of a cold windy environment.



[*Fox Photos*

FIGURE 2. *Cattle under severe weather conditions. Note that they are feeling the cold acutely, with erect hair coats and a typical stance*

It follows from this that owing to the effect of wind and cold skies, environments outdoors have greater cooling powers than air temperature measurements alone might suggest. A rough estimate of the number of days each year on which conditions out-of-doors are colder than those described by still air at freezing point in a room indoors, comes, from the Eskdalemuir statistics, to about a quarter to a third of the year!

At the Hannah Institute we have spent a lot of time measuring the effects of the temperature of the air on the heat losses of both sheep and cattle. Some comparable work with pigs has been done in Alaska and at Cambridge. These measurements have been made in respiration chambers in which air movement is low and in which the wall, floor and roof surfaces are kept at the same temperature as the air. Such conditions, while they may not be directly applicable to conditions outdoors where radiant temperatures and air temperatures can diverge and where the air is rarely still, nevertheless reveal some broad features of the ways in which animals combat cold and the magnitude of the effects of cold.

If sheep are clipped very closely to within 2 mm. of the skin, given constant food, and then exposed to different temperatures for periods of about a week,

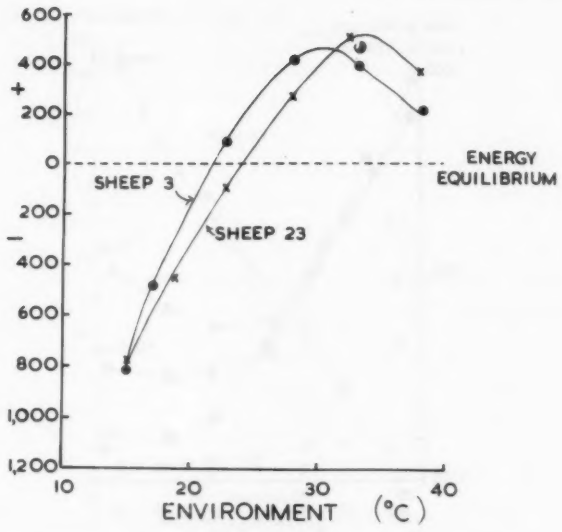


FIGURE 3. *The retention of energy by two sheep given a maintenance ration of food as affected by the temperature of the environment. The sheep were shorn to within 2 mm. of the skin*

results such as those shown in Figure 3 are obtained. The amount of energy stored in the body of the animal as flesh and fat passes through a maximum as temperature is raised. Both excessive heat and excessive cold result in a low productivity. These changes in gain are due entirely to changes in the animal's production of heat as shown in Figure 4. Both excessive heat and cold result in increases in heat production. Figure 4 includes results obtained when three different amounts of food were given to the same animal. The environmental temperatures at which metabolism first increases as conditions become colder is called the critical temperature. The Figure shows that the critical temperature falls with increasing food. It is also evident that in an environment colder than its critical temperature the animal's heat production is independent of the amount of food it is given.

Figure 5 shows the partition of the heat loss of this sheep by the major pathways, the sensible and evaporative pathways, at different nutritional levels. A small amount of heat is lost to the animal in a third way, for the animal warms the food and water it takes in to its body temperature. Heat losses by sensible means do not vary significantly with feeding level and, as might be expected, appear approximately proportional to the gradient of temperature from the body to the air. At temperatures below the critical temperature, heat loss by vaporization is small. Once the critical temperatures are passed, heat loss by vaporization increases as temperature increases and at about the same rate as sensible losses

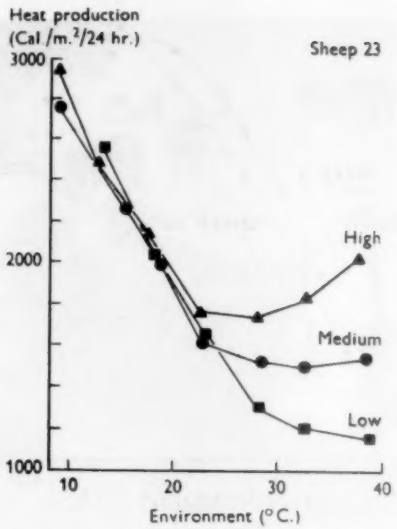


FIGURE 4. *The heat production of one of the sheep shown in Figure 3 when given high, medium and low amounts of food as affected by environmental temperature*

fall. The higher heat production of sheep given large amounts of food in a thermoneutral environment is thus entirely due to the fact that they vaporize more water. This same general picture in which sensible heat losses increase in proportion to the gradient of temperature from the body to the air has been demonstrated in experiments with adult pigs, baby pigs, adult cattle, man, and other animals. It is a general phenomenon in homeotherms.

It appears therefore that as it becomes colder an animal reduces vaporization to a minimum and then loses heat at a constant rate per degree centigrade gradient of temperature between its body and the air. This rate is dictated solely by the rate at which the animal loses sensible heat. It also might appear that the animal has little control over these sensible losses. It is of some interest, however, to attempt to measure the extent of any control which it has.

The increase in heat loss per degree centigrade increase in temperature gradient has the dimensions of a conductance, and its reciprocal the dimensions of a thermal resistance. Close analysis of the sensible heat losses in Figure 5 shows that a slight change occurs in their slope at about the critical temperature. This reflects physiological adjustments which the animal can make to its conductance. In these closely clipped sheep, the change in conductance is from 80–82 kcal in the cold to over 100 at an environmental temperature just above the critical temperature. The most striking adjustment is that the blood vessels of the skin constrict. Less blood then

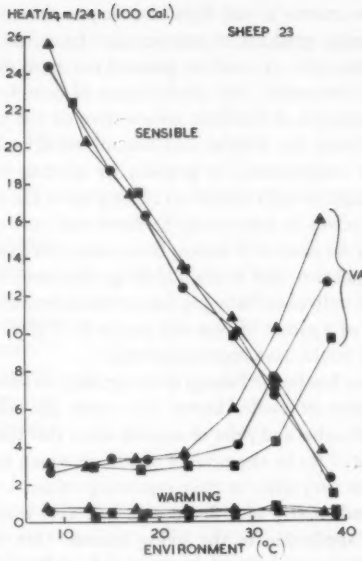


FIGURE 5. *The partition of the losses of heat by the same sheep as in Figure 2, into its three main components, the sensible loss of heat, the heat lost as water vapour and the heat used to warm food and water to body temperature*

flows to the skin and the insulation of the skin increases. This vasoconstriction appears to be a sudden event in time when an animal is exposed to a falling temperature rather than a gradual one spread over a wide temperature range, and it is certainly not an even effect affecting all skin areas equally. The constriction as judged by temperature measurement is maximal in the ears, the legs, and in cattle, the tail. It is discernible on the trunk none-the-less, but its magnitude there is smaller. In cold, therefore, the animal restricts the blood flow through those thin appendages which from their shape might be expected to lose a great deal of heat per unit of their surface. In most breeds of sheep, ears, face and legs are hair-covered rather than wool-covered, that is they are relatively poorly insulated. They in fact act as cooling organs at high temperature in animals with heavy fleeces. A second event occurring at the critical temperature is shivering. Our results with sheep show that the body movement associated with shivering appears to lead to slightly higher losses of heat by convection. A third event is erection of the hair coat. In cattle this achieves an increase in thermal insulation equivalent to an increase in a depth of the hair coat of 3–4 mm. Its significance is discussed later.

The question now arises, how much the animal can achieve by these alterations in blood and flow and blood distribution in terms of a reduction of the loss of

heat from the body. The answer is very little, for despite these large local changes in temperature the average gradient of temperature from its surface to the air changes by a few degrees only. It must be pointed out here that apart from the possibility of enhanced convection, the conductance of heat from the surface of an animal to the environment is constant irrespective of the temperature of the environment. The only way the animal can control sensible heat loss is by an alteration of its surface temperature, or possibly by altering the surface area it exposes to heat interchange by such devices as curling up in the cold and spreading in heat. In this regard, calves in severe cold lie down and curl up but adult cattle stand up more than they do when it is warm. Even more interesting in this respect is social temperature regulation, that is the huddling of animals in the cold. Mount has shown that while the individual baby pig has a critical temperature of 34–35°C., the critical temperature of a group of pigs was 25–30°C. Piglets act as a corporate body! No doubt Orwell would have appreciated this!

So far our consideration has been of sheep with virtually no fleece. The protection fleeces or, in the instance of cattle, heavy hair coats provide is considerable. Measurements made with skins and pelts of animals show that their insulating value is almost entirely accounted for by the amount of still air which they trap. The wool and hair fibres contribute very little to their insulating value. A physical measurement of the thermal conductivity of a fleece or a hair coat made on skins in the laboratory might seem applicable to the living animal. One might expect that insulation would simply be proportional to the depth of fleece covering. This is not, however, so in the living animal for several reasons. Firstly, not all the animal is uniformly covered by fleece or hair. Fleece on the trunk has no effect on the heat losses from the exposed face, ears and legs. Secondly, an animal with a fleece exposes to the environment a larger total surface. For example, a fleece three inches thick doubles the effective surface of the animal and it is the surface in contact with the environment which exchanges heat. This means that the effectiveness of a fleece covering in combating cold is not directly proportional to its thickness, but to about the logarithm of its thickness. A ten-centimetre fleece on this count alone can only be seven times as good as a protection as a 1-cm. fleece. A third reason why laboratory measurements may not give a good index of the insulation of a fleece is that the fleece can open when the animal moves and even slight movement can result in convection in the thinner outer layers of the fleece. With cattle, the additional thickness of coat achieved by piloerection is associated with a less dense mat of hair. It is possible that some free convection then occurs, particularly at the periphery of the erected coat and particularly if the animal shivers. This places emphasis on the importance of a dense undercoat as a protection against cold.

Table III shows our experimental observations on the effect of fleece covering on the critical temperature of sheep fed at the maintenance level. With little or no fleece this is about 30°C., falling to 20°C. when the fleece is 20 mm. deep. It falls to below 0°C. only when the fleece is above about 10 cm. deep. Adult cattle at a maintenance level of feeding have critical temperatures of 7°C. Our recent work shows that the young calf given limited milk has a higher critical temperature than it has in adult life.

TABLE III

THE CRITICAL TEMPERATURES OF SHEEP AT MAINTENANCE FEEDING LEVELS

Breed	*Fleece length cm.*	*Critical temperature °C.*
Down crosses	0·1	28–30
Hill breeds	0·1	28–30
Hill breeds	1·8	20
Down crosses	2·5	13
Hill breeds	4·0	8
Down crosses	4·5	8
Down crosses	10·0	3
Down crosses	12·0	−3

The above deals entirely with experiments in calorimeters. Outdoors the animal has to contend with wind and rain. The effect of wind in increasing heat losses has already been mentioned and it must be pointed out that my calculations of the cooling power of wind were made on the basis, first that the heat production of the animal was about that for maintenance, and, secondly, that the insulation of any hair or fleece coat was not destroyed by wind. The first assumption is acceptable, the second is not. Just looking at sheep in a wind shows that their fleeces do not remain perfect insulators and that wind penetrates them quite deeply. Nothing is known in a quantitative way about the insulating capacity of fleece or hair coats on living animals in winds except that in lambs, those with hairy coats and a thicker under pile have greater resistance to the combined effects of wind, cold and wet. Experiments on these aspects are in progress in Australia and Scotland.

With rain the destruction of insulation due to the presence of water in the fleece can be shown to be small. Effects of unknown magnitude are the heat lost in water which runs off the fleece or hair coat and the source of heat in drying out wet coats, though Alexander's work in Australia suggests that a lot of the latter is not provided by the animal.

We have determined the source of the energy which an animal uses to provide the heat to keep it warm when it is in an environment below its critical temperature. It appears to be entirely derived from body fat. No increase in the breakdown of body protein occurs. If the animal is growing there is some decline in the amount of protein laid down, because to deposit protein in growth involves an energy expenditure which is secondary to that necessarily used to maintain life under adverse conditions.

Several facts of agricultural importance emerge from these physiological and nutritional considerations. The first is that farm stock which are habitually

kept outdoors are not necessarily as resistant to the climatic vicissitudes of the British Isles as we often suppose. The most sensitive animal of all to cold seems to be the newly shorn sheep. The increase in machine shearing which in the most professional of hands leaves a fleece of about 6 mm. depth compared with about 12 mm. when hand shearing is used, certainly exaggerates a situation which the sheep must find difficult. In Australia late winter and early spring shearing of ewes has led to very considerable death rates, so much so that the practice is now being abandoned or the usual shears replaced by 'snow combs' which leave a longer fleece. In Britain losses of weight or poor gains in lambs shorn during the summer can largely be attributed to an effect of cold. Recent trials show that shorn lambs grew less well in the first month after shearing than unshorn lambs. If food is scarce so that heat production is low, then the critical temperature of the newly shorn sheep is likely to be about 25°C. If ample food is available, heat production will be much higher and the critical temperature will in consequence be as low as 13°C. Once the environmental temperature falls below the critical, whether it is 25°C. or 13°C., the sheep will lose 55 kcal/m²/24h for each centigrade degree of difference between the critical and environment temperature. Shearing is obviously a job to be abandoned if the weather is very cold and windy.

Turning now to the hill ewe, it is clear that with a heavy fleece of 10–12 cm. a sheep fed at about the maintenance level can withstand temperatures down to about –3°C., if there is little or no wind. Thus if sheep are kept at this feed level on many days each year they have to burn their own tissues to keep warm and alive. Really well fed and with this same fleece thickness, a hill ewe can withstand temperatures down to well below –25°C., colder conditions than we ever experience in this country. The importance of adequate nutrition in hill stocks is thus self-evident, and from our work it seems that any supplementary food should have maximal energy value per unit weight, rather than consist of high protein or high roughage rations. Hand feeding with starchy concentrates seems indicated. Though we know nothing about wind, provision of shelter from wind seems to me an essential. Animals have a strong instinct to seek the best local climate in a field on a hill or in a building, and the planting of shelter belts or even temporary shelter fences allows them to make better use of this instinct out of doors.

With cattle, outwintered stores growing very slowly have critical temperatures of about 3°C. to 5°C. The same beasts during fattening have critical temperature of about –7°C. Milking cows, with their higher food intake and higher metabolism, have critical temperatures of the order of –18°C. Milking cows thus require protection only under the worst of weathers. Such quantitative observations inevitably lead to questions about the economics of housing cattle with respect to their protection from the weather rather than with respect to the facilitation of their day-to-day feeding. A reasonable approach seems to be that buildings could well be provided if the interest rate on their capital cost does not exceed the monetary equivalent of any extra food needed to maintain production out of doors in the average winter. Calculations have been made of the approximate additional food costs of maintaining 1 lb. daily gain in a bullock under West of Scotland conditions, taking into account in the approximate way already discussed the effect of wind.

On average, to maintain this gain in the teeth of average Scottish weather entails spending about 18*s*. more on food than would be the case in a relatively simple cattle shed. Housing would be economically justified if it could be provided with capital costing less than 18*s*. per annum per head of stock. Similar sorts of considerations apply to the indoor wintering of hoggets. Here the additional food cost in an average winter is about 2*s*. per head. Comparable computations to these can be and have been made for other classes of stock.

These studies show that resistance to cold in stock is closely related to attributes of their hair or fleece coat. Under still air conditions, coat thickness is all that matters. In wind, however, the cohesion of the coat and the denseness of the undercoat becomes of importance. Water repellance is obviously important too. Here are aspects of importance in programmes of constructive breeding.

Finally, it does appear that in the past, much of our thinking about the effect of cold weather on our stock varied between the extremes of assuming either that they are indifferent to it or that their reactions are much the same as ours. The truth lies somewhere in between, and it is only in recent years that attention has been paid to the interactions of nutrition and physiological adjustments in stock under natural circumstances.

DISCUSSION

MR. F. W. HANKINSON, M.SC., B.SC. (Surrey Farm Institute): Would Dr. Blaxter indicate one or two outstanding wrongs in our present system? He says we are approaching it by two methods both of which are dead wrong. Are we wrong in one or two really bad instances?

THE LECTURER: We are wrong in so many aspects and so many things, of course, at the present time. In the provision of housing for farm livestock, I think that what we may be doing is giving a little bit too much attention to labour-saving aspects of house design, to the cost of labour-saving facilities, to the putting down, perhaps, too much in the way of concrete and particularly of metal which are not very nice conductive environments for our animals—and paying, perhaps, not quite sufficient attention to their needs for warmth and shelter which are, of course, the prime needs of animals. I think that out of doors we could do much more in the provision of very simple, very cheap temporary shelter, even on the hills.

The story on our hills is much the same as that in the opening up of the Middle West of Texas in the last century, and the battles between the cattle barons and the sharecroppers. There it was thought that fences should not be put on open ranges because they stopped the normal movement of cattle in snow and bad weather. Shelters can be put up so that they do allow the normal movement of cattle and of sheep on open country, such as some of the hill country of the Pennines, Northumberland and, of course, much of Scotland. There, I think, we could do a great deal, and the integration of the work of the Forestry Commission and of the farming industry could do much, I think, to help the general amelioration of conditions under which we keep stock.

MR. F. H. GARNER (Principal, Royal Agricultural College, Cirencester): I should like to ask two questions. We are hearing a lot to-day about the value of slatted floors for livestock. Has Dr. Blaxter done any work on comparing the comfort of the animals on slatted floors compared with a straw bed? He has referred to the comfort that sheep have with straw beds. I wonder if he has made any comparisons. In the last slide but one we saw that it was for ten or twelve days in the year—in winter time—

that one got the advantage from housing; but if you house stock for the winter you must house them probably for four to five months. You cannot have them in for just the cold days, so this rather understates the cost of housing as I believe Dr. Blaxter gave it.

THE LECTURER: With regard to your first question, I have not done any work on slatted floors from the point of view of their insulating value. There is quite a lot of information accruing, though, on types of injuries obtained, mastitis incidence and so on, on slatted floors.

I think your interpretation, or possibly my presentation, of the slide was a little bit wrong. What I meant was that the food cost was equivalent to ten to twelve days' food supply, not that you should house the animals for ten days only. In other words, out of doors you would have to feed the animals with food equivalent to another twelve days in order to achieve that rate of gain. This would be spread over the whole winter.

DR. F. E. MOON (Essex Institute of Agriculture, Chelmsford): I wonder if Dr. Blaxter has any information on the importance of the udder of the ewe as a site of heat loss, and has he any comments to make on the practice of tailing?

THE LECTURER: We do not know very much about the physiology of the udder from the point of view of its heat losses, but what we do know is that it is a most important temperature receptor. The whole of the inguinal area is an area of skin which reacts very violently to local temperature change. For example, Waites in Australia has done an experiment which is an extremely important one. He has shown that if you keep a sheep under very mild conditions and then heat it in the inguinal region it immediately starts panting. Its skin blood vessels dilate and it loses heat to such an extent that within about three hours its body temperature has dropped by eight to ten degrees. In other words, the whole of its heat loss mechanism which responds to heat goes into action, although, in point of fact, as a whole the sheep is in quite a normal environment. It is equally probable that this area of the animal is an important receptor from the point of view of the whole of this, the complex nervous regulation of body temperature. Farther than that I am afraid I cannot go.

With regard to the tailing of lambs, the usual practice, of course, on the hills is not to. On the lowlands, of course, it is. I think the reason why it is adopted is a lowland reason rather than a highland reason because, as you know, the lowland pastures are very much sweeter.

MR. J. R. FELL, B.SC. (Agric.): To me one of the most fascinating parts of Dr. Blaxter's lecture was that where he showed the diagram of the skin temperatures of the reindeer. It reminded me of reading about an experiment carried out some years ago in Norway with men from the Norwegian Army. These men were on the mountains and they could withstand conditions which we here could not stand. The point of this experiment was that these men returned to barracks for only a single night, and became accustomed to sheets and blankets, and they could not go back the next day. It took them at least a fortnight to regain those skin conditions, because their arteries close to the skin contracted so that the metabolism of the skin was pretty dormant.

Putting that experiment side by side with what we have heard, it would appear to me that a sudden spell of inclement weather is far worse than the gradual onset of autumn.

THE LECTURER: I interpret those experiments in rather a different way. They have been repeated by quite a number of people now in the Arctic on the Fuchs Expedition and with Australian aborigines and so on. The crux of the matter was that the men could sleep; they could really sleep. The Australian aborigine, for example, will go

to sleep out in the Australian bush under conditions of cold in which we Europeans would be very uncomfortable indeed. Several people have been down to Australia to measure how much oxygen the Aborigine consumes. He consumes exactly the same amount of oxygen in the cold as does a white man, an ordinary unacclimatized one laying next door, but he can tolerate these low skin temperatures and sleep, whereas a white man shivers, is extremely uncomfortable and cannot get a wink of sleep all night. In other words, the acclimatization is an acclimatization in being able to sleep rather than an acclimatization to cold *per se* in terms of minimizing its effects.

MR. J. W. FRATER: Dr. Blaxter mentioned the degree of insulation from the skin of sheep; can he tell us anything about the degree of insulation from the hoof? He did say that the hoof was insulated. We see that our sheep, when left to themselves, go to a considerable amount of trouble to avoid muddy and damp patches, yet, as lowland farmers, we are inclined quite often to put them to live in muddy conditions during the winter. Are we being completely foolish in doing so?

THE LECTURER: The major part of the insulation of an animal's body if it is on nice high ground is an air insulation. If we put the animal in water the insulating properties of water are very, very different from those of air. Experiments which have been done with regard to survival of man at sea, for example, show that in water the heat loss from the body is accelerated by a factor, I think, of the order of eighty times that in air at the same temperature. The thermal conductivity of sea water is very much greater than that of air and so, understandably, in water, man loses more heat than he does in air at the same temperature. Sheep's feet presumably do the same. It would seem that animals which are up to their hocks in mud, which is presumably cold mud, must be losing heat at a great rate. We do not know very much about this. This is what I think might probably occur. I do not know whether experiments have been done on this but it is obviously something which is very important.

MR. T. B. BODEN, J.P.: Could the speaker tell us what the connection is between this heat loss and pregnancy? It is a fact that an animal which is pregnant does not seem to winter so badly as one which is barren.

THE LECTURER: With pregnancy there is an increase in the amount of heat produced by the animal. Even if she herself is losing some weight in order to build up the new tissue of the foetus and the membranes that go with it, she is producing a great deal more heat. She also, of course, has a greater appetite. In the earlier stages of pregnancy, at any rate, she forages more avidly and she is certainly producing more heat.

There is one very interesting aspect of the hill ewe in cold, and that is the loss of fleece which occurs under cold privation. For instance, about two years ago on Loch Ness-side after a very severe winter there was a great loss of fleece; that is to say, the whole of the fleece peeled off the animal in response to a really severe climatic stress. It was really remarkable; it seemed a most peculiar thing to happen but it appeared to show that the combination of starvation and really severe weather, plus sometimes a little bit of infection, leads to this complete loss of the animal's fleece. Then if really severe weather comes the animal dies. It is common and seems to be more common in pregnant animals, that is, more common in pregnant animals than in store stock.

MR. T. W. GRIFFITHS, B.SC., F.R.I.C.: Would Dr. Blaxter care to comment on the optimum temperature at which he thinks one should keep fattening beef cattle?

THE LECTURER: I do not like to think so much about a best temperature as in terms of an optimal range, which is very wide. I take it that for fattening beef cattle you are thinking of two pounds a day?

MR. T. W. GRIFFITHS: Yes.

THE LECTURER: I thought you would be. These cattle can withstand air temperatures down to minus five or minus six. It may not be economic for you to protect them for very extreme conditions. The most important thing is to protect them against wind. At the other extreme, it is not worth while doing anything at all about trying to keep the buildings particularly cool because you are not going to get hot conditions during the time of the year when they would be in the house. Broadly speaking if temperature goes down to below freezing point you need not worry very much. The upper limit can be the upper limit imposed by the environment out of doors. I would not go to the expense of a well insulated building because the temperature in that building will probably be too high. Quite a simple structure is sufficient, provided you have just that small degree of insulation that brings you up above this figure of minus five.

MR. J. A. MONTGOMERY: In the earlier part of the lecture diagrams were shown comparing the average temperature at Kew and at a place on the west coast of Scotland. This was the mean average temperature for the full twenty-four hours per day, I presume?

THE LECTURER: Yes.

MR. MONTGOMERY: I wonder if sufficient recognition has been taken of the effect on animals of the difference between day and night temperatures. It would have been interesting if we could have been shown the variation of the mean average temperature between day and night at the two places, and I should have expected bigger differences at Kew than in Ayrshire.

Now how important is this day and night variation to animal comfort? The results of Dr. Blaxter's experiments seem to indicate that housing for horned stock has a very limited commercial value, yet it is common practice on most farms to house cattle in winter. Could it be that the experiment in controlled conditions of static temperature day and night, might not properly compare with conditions on the farm where the day and night temperatures are substantially different, and so lead us to wrong conclusions?

THE LECTURER: There have been experiments carried out on these lines in which, quite deliberately, a diurnal swing of temperature has been studied. There is one remarkable thing about animals and that is they do alter their average body temperature. Their central body temperature may remain constant, but their average body temperature is certainly not constant over twenty-four hours. For example, their skin temperature changes. The temperature of subcutaneous tissue can fall. Its temperature is not that of the central mass until about eight or nine or ten millimetres below the skin. It is not the same temperature as the temperature right in the middle of the liver. That means that, under short exposure to cold, animals can lose body heat, and under heat they can gain some.

Professor Herrington of Harvard calls this phenomenon in which the actual heat capacity of the tissue is used to tide over such things as diagonal variation 'body mass equilibration'. There is certainly quite a lot of evidence to show how it comes about. Quite recently Gonzalez from Venezuela, working in our department, has been measuring the effect of changing temperature on young calves, and he finds it takes about three and a half to four hours for a calf to respond to a fall in temperature. It does use this general body cooling at the beginning, at any rate, before it starts to respond by producing more heat. In other words there probably is something in what you say. A variation with really bitter conditions in the middle of the night may be more important than the average temperature, but all we have got at the moment to go on is average 24-hour values. Indeed, my figure of 18*s*. per cattle beast is an under-estimate. I think it is somewhere probably nearer 25*s*. to 30*s*. at present prices.

Does that answer your question?

MR. MONTGOMERY: The further explanation is very helpful, but if you lead us to go away and deduce from the experiment that winter housing does not pay, when we in the past have thought it does, it is important that we realize that the conditions of the controlled experiment differ from those experienced by our animals on a winter's night.

THE LECTURER: Well, it does pay about 18*s*. a head as a minimal estimate, which is quite a lot of money. You can buy quite a reasonable cattle shed for a reasonable head of stock for the winter.

MR. P. K. SHAHANI: In his experiments did Dr. Blaxter consider any of the radiation effects and, if so, what were the methods he employed in finding out the effects?

THE LECTURER: Infra-red radiation and solar radiation? Well, we have not measured solar radiation effects at all. We are hoping to go on to those in the course of this coming winter. We have separated the effects of radiation and the joint effect of convection and conduction in the calometric experiments. They are not all that interesting, really, and I have not presented them here to-day. I mentioned earlier that the radiation environment may be several degrees colder than the temperature which contributes to making this figure of 18*s*. a very minimal one.

DR. H. E. LEWIS (Division of Human Physiology, Medical Research Council): I should like to say how much I enjoyed trespassing in your fields, because some of the subjects which we are now dealing with in the Division of Human Physiology are concerned with the exposure of polar explorers and it is very interesting to see so many points of analogy. We are interested in the layers of clothing necessary in the cold; we are also very interested in the amounts of food our colleagues eat when they are in these polar extremes, and it was interesting for me to see that in animals, depending on how much they eat, there can be a change of critical temperature and thus a change of metabolic economy.

However, I really want to say that the assessment of climate is something which is concerning us very greatly at the moment. As you know, a polar traveller is looked upon as a very heroic person who has been exposed to the cold of the Arctic and the Antarctic. But when you are actually there this is the last thing you want to do; you don't deliberately go into blizzards, you try to shelter yourself, you stay in a warm tent or a base hut when the weather is bad. Besides that, you wear carefully designed clothing to protect yourself when you have to go out. Now, how do we assess the real exposure? Like yourselves, we find that the 'met' data are just not suitable or good enough for human and biological purposes. One advance has been the development in our laboratories of temperature-sensitive watches, and if a man goes out of doors wearing, say, three of these watches, each set to stop below a different temperature, at the end of a day you will know precisely how long he spent in the various temperature ranges. We have been using other methods in addition, similar to time and motion study, to record the patterns of activity; but I thought you might be interested to know of these watches, designed by Mr. H. S. Wolff, since they could be used to study the cold exposure of animals.

THE LECTURER: I am very interested to hear those remarks and I certainly will teach my sheep to read the time!

It sounds an extremely interesting thing for us to try, to get an idea of what environment an animal seeks. You see, our sheep and our cattle too have this—I think Benzinger called it the 'Pavlovian'—temperature regulation sense which produces information about the feel of the climate. When a man says, 'I'm going indoors now', or, 'I'm going to have a small whisky', the sheep says, 'Well, I am going to get into some shelter'!

MR. J. T. RICHARDSON-JONES: Has anything been allowed for stress conditions of

cattle having to lie in damp wet ground? We are told that they do not need the shelter, but I rather fancy we usually put up a shelter and put somewhere for them to lie down. I come from Wales, and our rainfall is very heavy.

THE LECTURER: What we measure and have noted under our very highly specialized conditions is that in cold and in heat cattle stand very much more. The optimum temperature for maximum lying down time is about 15 degrees centigrade. In other words, if one uses this as the animal's subjective measure of how comfortable it is, then 15 degrees centigrade for a cattle beast is the most comfortable temperature. Then it lies down the most. Heat losses to floors, to the ground and so on, can be very large indeed. The normal heat loss from a square metre of a bullock's surface per day is of the order of about 1,000 to 1,200 calories per square metre. The loss, if it lies down on a wet concrete floor, even though the floor has got those little air holes in it which the manufacturer tells you will prevent heat loss, can be about four to five times as great from the area which is in contact

We know absolutely nothing about how the animal deals with this particular problem. How does he deal with the problem of maintaining constant body temperature when the part of him in contact with the earth is losing heat at a rate which is about five times the other part of his body? These losses on lying are quite considerable, but under cold animals do not lose anywhere near as much as they do at equitable temperatures, and the energy expense involved in standing up all the time is not more than about 5 to 6 per cent. of his total expenditure of energy. It is another thing that starts putting up that figure of 18*s.* again and again. As I say, it is a minimal estimate; it is the only one we can make.

MR. F. H. GARNER (Royal Agricultural College, Cirencester): Nothing has been said about breed, and we do not know much about the way in which different breeds react under cold conditions. Is hardiness due to the covering on the animal, the hair or the fleece? Is it due to the thickness of skin or is there a difference in metabolism within the animal to account for a difference in hardiness?

THE LECTURER: We have tried to have a look at this as far as sheep in still dry cold are concerned. Under conditions of still, dry cold, that is to say when there is very little air movement and the fleece is dry, the only criterion of the insulating value of the fleece is its depth measured with a probe. Blackfaces have a fleece which grows at about twice the rate of Cheviots, but per inch of effective depth their insulating value is about the same. After shearing a Blackface will put on about twice the amount of fleece depth in the initial stages of wool growth as a Cheviot, and at equal times after shearing the Blackface will be the better protected against the weather of the two.

When it comes to wind and wet it looks as if the important thing is the nature of the undercoat. It looks very much as if the important factor is the tightness with which the undercoat of the animal prevents the access of wind. We can measure this sort of thing by comparing sheep and cattle, measuring the insulating value of wool in sheep and hair in cattle. The dense fleece of the sheep at equal lengths has got an insulating value which is about 25 to 30 per cent greater than that of the rather more sparse cattle coat. This difference we think arises due to convection, that is transfer of heat within the interstices of the coat in the case of cattle. What seem to be necessary for protection against cold are all the attributes of fleece which the Wool Marketing Board does not like!

MR. W. A. G. CHARLESTON, B.V.SC., M.R.C.V.S. (Department of Veterinary Anatomy, University of Bristol): Could Dr. Blaxter enlarge upon his thoughts on the effects of temperature on feeding behaviour, rumination and appetite?

THE LECTURER: The evidence is quite clear, that under cold there is an increase of voluntary intake of food by animals. Under heat, intake declines. The nature of the

control mechanism is not perfectly understood. It is probably thalamic, that is to say, in the brain stem. It seems highly probable that there are synaptic connections between the pre-optic areas of the hyperthalamus concerned with the heat loss mechanism and the nuclei which is concerned with appetite regulation. That is the probable mechanism.

But explanations apart, it is pretty well an established fact that they eat more when it is cold, which is a point which has to be considered in relation to the housing of stock from the point of view of maximum production. There may be an optimum temperature with respect to maximum food intake in terms of gain. All the evidence I have, however, indicates that the limit of a temperature for an animal is given solely by its critical temperature or two or three degrees above. There is no other factor you have to consider.

MR. HENRY STEVEN (President, N.D.H.A.): Dr. Blaxter, in his talk, said practically nothing about the lactating animal. One has cows giving fair quantities of milk; one presumes that in order to produce that milk they are producing energy, and whether it is desirable to be able to dissipate it rather than to conserve it, is questionable.

THE LECTURER: The problem, as I said earlier, is that the cow is most heat sensitive; that is to say, she cannot tolerate heat. She is the most sensitive of all our livestock to heat. Many of our byres, I think, are too hot, especially some of the little stone byres.

An example of this is the case of the cowman who has had rather a rough kind of day and plugs up the ventilators to get up a good temperature for when he comes in to do the morning milking. That is very, very bad for cows. They do need the capacity for losing heat, and they do not like too hot an atmosphere. Broadly speaking, however, they can stand quite low temperatures. Some very interesting work has been done in the last 18 months in Holland (where they get more severe winters than we do), by putting heating plates in open yards under loose housing conditions and watching how cattle behaved. The results were very interesting. The animals which went to the heated plates seeking warmth were the dry cows and the low yielders, and the high yielders kept away. The high yielders are perfectly happy at quite low temperatures, that is, temperatures of minus 10 to minus 15 degrees centigrade, whereas low yielders are not.

THE CHAIRMAN: May I now reiterate what I said at the outset, that we in the Royal Society of Arts are extremely indebted to the magnanimity of Plant Protection Limited in making possible this Fernhurst Lecture. The Society is happy to provide a platform and a forum that will enable the scientist to come close to the practical farmer and vice versa. You, in fact, by your sustained questioning for 37 minutes, have indicated to Dr. Blaxter how much you appreciated his lecture to-day, and I am sure I shall be speaking in the name of Plant Protection, the Royal Society of Arts and you, Ladies and Gentlemen, when I express a very deep sense of gratitude to Dr. Blaxter for his fascinating address.

The vote of thanks to the lecturer was carried with acclamation, and the meeting then ended.

THE TRAINING OF SCIENTISTS AND ENGINEERS FOR INDUSTRY

The Trueman Wood Lecture by

SIR JOHN COCKCROFT, O.M., K.C.B., C.B.E., F.R.S.,

Master of Churchill College, Cambridge, delivered to the Society on Wednesday, 26th April, 1961, with Oswald P. Milne, F.R.I.B.A., J.P., Chairman of Council of the Society, in the Chair

THE CHAIRMAN: This series of lectures was founded by friends and admirers of Sir Henry Trueman Wood, who was for 38 years Secretary, and subsequently Chairman of Council, of the Society. The lecture has generally been devoted to some subject connected with science and engineering, and it has always been given by men very distinguished in their particular spheres—men such as Sir Oliver Lodge, Professor Oliphant, Lord Rutherford and, last year, Sir Bernard Lovell.

To-day we are privileged to hear a man no less distinguished than his predecessors in this hall, and we can have no doubt that his subject is one of the utmost importance. In every journal you read about the necessity for more scientists, more technicians, and more engineers, and every education authority is exercised about the matter. I think perhaps we tend to become slaves rather than masters of our machines, but they need tending, repairing, they need looking after, and we must have a stream of people able to do those things. Possibly by this very process and by their success, the engineers and scientists may work themselves out of a job, for when they have brought automation to perfection it may be that all we shall have to do is touch the right buttons and the machine will not only make things but think for us as well; but that time is not yet, and in the meantime who could we have better than Sir John Cockcroft to tell us how to keep up and increase the supply of the engineers and technicians which we need to support our economy?

The following lecture was then delivered.

THE LECTURE

In considering the training of scientists and engineers for industry, we should note that the terms scientist and engineer cover a very wide range of human beings. At one end of the spectrum there are scientists whose work is mainly devoted to the acquisition of new knowledge with little or no thought of any practical applications. Most of these scientists work in universities though there are some in Government Establishments and Research Council Institutes. Next in the spectrum are the applied scientists and technologists whose work has a practical objective; some of these will be working on projects whose realization may be up to twenty years ahead; the majority will be working on projects being designed or constructed. The engineers merge almost imperceptibly into the applied scientists. At the recent M.I.T. Centennial Conference on Technological Education Professor Gordon Brown divided engineers into three broad groups. The first is the creative

group, who 'have the talent for conceiving from abstractions or from the broad body of science wholly new superior devices and systems. They are composers rather than arrangers. Their work is predominantly intellectual and is dependent on a profound knowledge of science. They practise the art of forcing technological change.' In this class are the pioneer microwave radar engineer-physicists, computer engineers, reactor engineers, the jet engine pioneers. The second class are those who

> can devise and build systems of engineering works by an orderly, creative, ingenious arrangement of the new knowledge of the day. They are more the creative arranger than the composer. This type of engineer works in close harmony with his colleagues in the composer category. He appears in great numbers in development laboratories, in design establishments, in production, manufacturing and planning.
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> The third group are persons engaged in assembling, operating and maintaining complicated machines and engineering works from drawings, descriptions, or from experience. In one sense they are the custodians of technology. They are not second-class citizens. In both to-day's and tomorrow's era of technology they are needed in very great numbers.

The labels on individuals change with time as they move from science to technology to management. Our policy underlying the training of scientists and engineers for industry should be based on the undoubted fact that scientific and technological development is proceeding more rapidly than at any time in history and that the pace of development is accelerating rather than diminishing. It is furthermore impossible to foresee the course of scientific discovery more than a few years ahead—no one working on nuclear transmutations in 1933 had foreseen the possibility of artificial radioactivity, so that it was discovered by accident rather than by deliberate experiment; Rutherford at the time of his death in 1937 could not foresee nuclear fission or the possibility of a chain reaction; 15 years ago we could not have foreseen the discovery of the transistor. It is on the other hand possible to foresee with reasonable clarity the course of technological development ten years or so ahead once its initial development is well established. We can foresee the types of nuclear power stations likely to be in operation in the early 1970s, and no doubt the aeronautical engineers have a good idea of the types of aircraft which might be flying by then; communication engineers have probably clear ideas of how communication engineering will develop during the next decade, and the builders of multimillion pound chemical factories or steel works must have a good ten-year view of the future ahead.

During the last decade piston engines have been superseded by turbo-props and in turn by turbo-jets, and already for military purposes jets are being replaced by rockets. Radio circuitry and devices based on vacuum tubes are being replaced by transistor circuitry and this in turn is in course of rapid development and change.

For these reasons the training of scientists and engineers for industry should be training which will enable them to deal with the technological developments of the future rather than the problems of the past. This requires that the university training should have a strong component of basic science. The students should become thoroughly familiar with the fundamentals of electricity and magnetism, so that they can design electrical equipment from first principles rather than from

handbooks. They should be familiar with the principles of heat and thermodynamics; with fluid dynamics; and with the modern physical explanation of the behaviour of solids, known to-day as solid state physics, since this is the basis for the understanding of the numerous solid state electronic devices which are changing the face of technology to-day. All this basic training should be illuminated and made possible by a good working knowledge of mathematics, particularly calculus and differential equations. Mathematics should indeed take priority over all other subjects in the training of sixth-form scientists who intend to proceed to a university or industry. At the university the training should be in theoretical physics rather than mathematics. There is to-day too much of a divorce between mathematics and physics in many universities. Mathematical theory is steadily becoming more abstract and divorced from the physical world. Scientists and engineers are interested in the applications of mathematics rather than the development of mathematics.

Training in classical physics should of course be combined with an understanding of the nature of atomic structure on which everything depends, and it is impossible to-day to leave out an account of radioactivity and the effects of radiation on materials and living organisms.

Nevertheless, there is much in nuclear physics, and particularly high-energy nuclear physics, involving the study of the strange nuclear underworld, which could be omitted from a three-year first degree course and left to a specialist post-graduate year for students going on to do research. It is important also that in the first one or two years of university training the course should include physics, chemistry and mathematics, since this provides a broader base for research work than any one discipline alone. From this point of view the Cambridge Natural Sciences Tripos Part I, in which three or more sciences, including mathematics, are studied, is a good model. This is usually taken in two years but it is possible for students trained to a high level in one of their subjects at school to take only one year over this subjects at the Part I level, leaving more time for intensive study of the specialist subject at advanced level.

Many of the same general principles should be applied to the training of the engineer. In my view the first two years of undergraduate training of an engineer should be devoted to engineering science embodying the scientific principles which underly his technology. Only after this is inculcated should he begin to specialize and spend a large part of his time on electronics or thermodynamics or power engineering or other specialist subjects. Even then we should take note of the fact that technology is tending to become more and more interdisciplinary in character. Nuclear engineers must work with radiation chemists, metallurgists, health physicists and reactor physicists, taking their individual contributions and weaving them into a composite design. Design engineers should also receive some training in the visual arts, for design problems are essentially three-dimensional—they need to be artists as well as technologists. When I was a student apprenticed to Metropolitan Vickers I remember my friends who were interested in turbine design being instructed to go about the shops with notebooks sketching the equipment they saw around them.

Design engineers should also receive some initiation into the complicated and intuitive process of decision-making, taking the innumerable variants of design open to them, and selecting that which will be most economical in capital cost, most economic to run and easiest to maintain. In this process of decision-making an engineer will be greatly helped by the modern digital computers, which can ring the changes on a large number of variables in comparatively a very short space of time, and thus compare the relative economic merits of different variants. At the recent M.I.T. Conference it was pointed out that a spur gear train can be designed by a computer at a cost of 50 cents.

Dr. James Killian, now Chairman of the Board of M.I.T., said in an address to the Parliamentary and Scientific Committee last year:

> New foci of engineering studies are appearing, including information theory, magneto-hydrodynamics, nuclear engineering, systems engineering. With technology changing so fast, engineers must become more open-minded, more concentrated on the hard core of fundamentals, so that the engineer will have the versatility to adapt himself to new technologies, some of which will not even be known when he is in college.
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> Together these new goals seem to presage an increasing number of institutions dedicated to programmes that are less vocational and specialized at the undergraduate level, fundamental in their basic science and advanced enough in the mathematics and humanities to educate a new breed of engineer more adapted to our changing technology, the kind of engineer we are desperately short of in the world to-day.

Training in social sciences should become an important part of the undergraduate curriculum. All M.I.T. undergraduates have to study at least one subject in the School of Humanities and Social Sciences throughout each of their first two years. In the second two years they are required to take four courses in the school, each lasting one term.

I am not qualified to speak of the training in other disciplines, the training of the chemist or metallurgist, but I think that many of the same principles must apply. Chemical engineers will be faced with the problems of materials technology, problems of energy and mass transfer, problems of fluid flow and thermodynamics, as well as the basic chemistry of the processes they are applying. The Institute of Chemical Engineers some time ago recommended that about 45 per cent of the teaching in a university should be devoted to pure science and mathematics; about an equal time to chemical engineering science, and the remainder on other engineering science, report-writing and a foreign language. A later study of the work of practising members suggests that a greater proportion of the time, up to 25 per cent, should be devoted to social science and communication—report-writing and languages. The metallurgist of the future must have a good understanding of the behaviour of dislocations in crystal planes which determine the plasticity and brittleness of the metals. The theory of alloys is likely to change greatly during the next ten years from its present somewhat empirical state and become a more scientific subject. The development of ceramics capable of withstanding very high temperatures is making rapid progress based on increased physical understanding.

The greatest concentration of scientists in industry is at present in fields such as

electronics, aeronautics, guided missiles and atomic energy and applications of solid state physics. The scope of scientists in the heavy electrical and mechanical industries has been very much extended, and to-day these industries will often take physicists just as readily as engineers.

There has been a great deal of discussion about the importance of post-graduate research for the scientist or engineer going into industry. Some industrialists think that time so spent is largely wasted so far as they are concerned, since the subjects of research will usually bear little relation to the work they will be engaged on in industry. A nuclear physicist helping to build a giant accelerator or to carry out experimental work with it will certainly not work on these problems in industry unless he is engaged in the design or construction of such equipment. On the other hand, he is certain to acquire experience of the most advanced vacuum technology in the world, experience of very high speed electronics, timing nuclear events down to a thousand millionth of a second, the behaviour of large volumes of liquefied gases, hydrogen or helium, larger than have ever been dealt with before, and he will have to be able to use the most modern computers and be skilled in writing programmes for them. He will also have to get used to team work, which is an sset for work in industry.

In a similar way, if he is a radio-astronomer his objectives will be far from the problems of industry, except the embryo space industry, but he will become familiar with large structures, accurately aligned arrays of aerials, an accurate feeding of these arrays with microwaves or longer waves, and again with very sophisticated electronics using the most sensitive microwave receivers in the world.

On the other hand, there are some subjects for postgraduate research which are of little use for training a scientist going into industry.

There is, however, one important aspect of postgraduate training which should not be forgotten: that is the reading of original current scientific literature, and attendance at the innumerable colloquia which characterize a university such as Cambridge. When I was a Research Student in the Cavendish Laboratory, we used to have weekly colloquia in the laboratory, and in addition on one evening in the week I went to meetings of the so-called 'Kapitza Club' to discuss the most important of the recently published papers—so we followed the development of wave mechanics, quantum mechanics, the uncertainty principle, and the great development of experimental physics in the late 20s and early 30s. In one week at Cambridge recently I listened to an account of the latest developments in superconductivity, to Professor Fred Hoyle on the origin of the planets, and to Professor Denis Wilkinson on the structure of the nucleus, and I could no doubt have been to several other equally interesting colloquia.

There is no unique answer as to whether scientists are best taken by industry at the end of their undergraduate career or after they have done some years of postgraduate research. At Harwell we took about half our scientists at the end of the undergraduate career and about one half after a research period.

In the United States more weight seems to be attached by industry to the Ph.D. than is usual here. But this may be due to the fact that American scientists really

begin to develop fast during their intensive three-years Ph.D. work—more intense than anything here; so much so that our graduate physicists arriving in United States research laboratories are often considered to be 'uneducated'.

In the course of Dr. Killian's address to which I have referred he said that 'in the United States, graduate study for the Ph.D. in engineering is a growing requirement. The United States needs to have more graduate engineering schools as good as the best we now have. Graduate engineering education depends heavily upon advanced mathematics and theoretical physics, on quantum theory, on Boolian Algebra, on number theory; solid state physics, nuclear structure and other subjects formerly considered too theoretical for engineers now have solid engineering applications.' Very few of these subjects are taught to graduate engineers to-day in Britain.

Dr. Killian also stressed the importance to both science and engineering of developing interdepartmental laboratories or graduate centres which represent a federation of disciplines. The M.I.T. Research Laboratory of Electronics brings together mathematicians, electrical engineers, physicists, psychologists, linguists and physiologists. A large graduate centre is being established in Earth Sciences, bringing together geophysicists, geologists, mineralogists, meteorologists and oceanographers. Other graduate centres are being considered for materials technology and aeronautics and astronautics. In the creation of such interdisciplinary departments we are so far almost non-starters.

The development of United States technology has been greatly helped by the work of the great graduate schools. The work of Vannevar Bush in the 1930s started the rapid development of computers in the world; the Department of Instrumentation has been responsible for the development of guidance systems for rockets; their Department of Engineering is doing pioneering work on new methods of converting heat energy to electrical energy.

There is a great advantage in such pioneering research being associated with teaching. The research work is fertilized by a continuous flow through the schools of the best young brains of the day, whilst the new knowledge is continually diffused downwards by teaching whilst it is fresh.

Besides the scientific and technological content of a young scientist's training, industry to-day attaches considerable importance to its young scientists and engineers being reasonably literate. When they arrive in industry they should be able to read at least one foreign language, and they ought to be able to write concise, intelligent reports and papers on their work for technical journals. They ought also to be able to explain their ideas and work in intelligible language.

Sir Charles Snow in his lecture on *The Two Cultures* has summarized his experience in interviewing 30,000 to 40,000 young scientists in the war years and since then as a Civil Service Commissioner. He said, 'Some of the best scientists had and have plenty of energy to spare and we came across several who had read everything that literary people talk about. But that is very rare. Most of the rest (when we tried to press for what books they had read) would reply "Well, I have read a bit of Dickens".'

A recent report of the University of Birmingham Physics Panel on science

syllabuses said amongst other things that 'the general educational background of many university entrants in physics is thin, and their style of written English is immature. This seems to be at least partly due to premature specialization, though home background is also important.'

The more comprehensive Leverhulme report on *The Complete Scientist* concluded that the deficiencies in literacy arise from the fact that the average time devoted to English Literature in the sixth form is only two periods of 40 minutes, and there is only one period devoted to languages. Practically none of the private study time or homework is devoted to promoting literacy.

The reason for this neglect of the Arts by Science students arises from the present great competition for entry into the universities, and particularly the competition for entry into the colleges of Oxford and Cambridge and for the open scholarships. A good deal of discussion is now going on in university circles to see how this can be mitigated. One of the essential requirements seems to be to give enough weight in entrance examinations to non-specialist subjects as well as to specialist subjects. The Trinity group of colleges, of which Churchill College is a member, have for the first time required all candidates for entrance to sit either for the open scholarships or for a general entrance examination in which appreciable weight is given to performance in a non-specialist paper.

When a scientist or engineer enters industry he can benefit very much from a further period of training. Most large organizations now have Induction Courses to interest new entrants to the industry. Beyond this there should if possible be frequent colloquia at which the latest scientific and technological developments in the field of the organization are presented. At Harwell we had weekly colloquia in most of the Divisions in addition to Establishment lectures on more general topics. Sometimes university lecturers used to be invited to deliver a course of six or so lectures at advanced level.

The Bell Telephone Laboratories of the United States, one of the most highly developed and successful technological organizations of the world, have a settled policy of giving their new entrants an intensive, very advanced course on the specific development problems, design problems and engineering problems of the laboratory. Dr. Mervyn Kelly has said that 'the more basic the curriculum to which he has been subjected in the university the better job industry can do in its supplementary programme'. I have no doubt that such training is of great advantage to industry.

In some industrial organizations new entrants are also sent for short courses of general studies which include lectures on current affairs, relations with other countries, and similar topics. This is a good way of continuing the general education of the scientist.

Beyond this there is a need for refresher courses for scientists in industry to make them familiar with new developments which are likely to affect industry. British universities are now offering a wide variety of one-year Diploma Courses. The University of Cambridge offers Diploma Courses in Mathematical Statistics, Numerical Analysis and Automatic Computing, Control Engineering and Structures, and is establishing similar courses in Chemical Engineering, Industrial

Management and possibly in Metallurgy. British industry is to-day too reluctant to release their staff for such refresher courses.

In the United States, M.I.T. arrange a large number of courses of about three weeks duration in the summer months on highly specialized subjects such as Mechanical and Physical Properties of Plastics, Shear Strength of Soils, Reliable Long Range Communications, Industrial Public Relations, Plasma Dynamics, Industrial Dynamics.

One of the objectives of Churchill College is to provide accommodation and facilities and tutorial supervision for students from industry coming to Cambridge to take such courses.

I have not so far discussed whether we are training enough scientists and engineers for the needs of industry. Long-term predictions of requirements are often uncertain, but predictions three years ahead have in the past turned out to be fairly accurate, the overestimate for one industry being counterbalanced by underestimates in others. The Committee on Scientific Manpower of the Advisory Council on Scientific Policy reported that there had been an increase of 30 per cent in the number of scientists and engineers employed in manufacturing industry between 1956 and 1959, and that an increase of about 22 per cent would be required by 1962. In addition to this about 14,000 would be required to replace losses by retirement, death and emigration. It appears that the number of scientists and engineers who should be trained by universities will double in a time of roughly ten years, and that we shall need an annual output of new graduates in pure and applied science of about 20,000 a year by the mid 1960s. Our annual *input* to the universities in 1958-59 in these departments was about 13,500; so we have to continue the steady growth rate of the past.

One of our major deficiencies at the present time is in the output of mathematicians. The employment of mathematicians has increased by about 50 per cent in the last three years, due no doubt in part to the applications of computers in industry, so that the supply of mathematicians now seems to be quite inadequate for industry, government and the schools. As usual the schools are taking the brunt of the deficiency, and at the January Conference of the Incorporated Association of Headmasters it was stated that the Direct Grant Schools had only been able to fill 61 per cent of their vacancies during the last year, and that the teaching of mathematics in the schools was in a serious state. The only remedy for this is to increase the size of the schools of mathematics in many of our civic universities. There are at present about 760 students in their final honours year at all universities, about 460 at London, Oxford and Cambridge. The other universities contribute about 300, ranging from 47 at Manchester to four at Cardiff. So the number at many universities is now far too low. This seems to be connected with the reluctance of many students to embark on training in advanced mathematics owing to the high standards demanded in the courses and the increasingly abstract nature of the training. Many headmasters would welcome a supply of mathematicians trained to a somewhat lower level but adequate to do sixth form teaching. We need new model university courses in many civic universities designed to satisfy this need and also to provide mathematicians for industry.

We may also have to pay still more attention to the supply of engineers and technologists. At the present time we have major schools of technology in Birmingham, Cambridge, Durham and Newcastle, Leeds, and Sheffield on the scale of about 1,000 students each. This seems to be about as many as can be accommodated in a normal university without distorting the balance of the university. It would certainly be impossible for the University of Cambridge to increase its numbers by more than 10 to 15 per cent beyond the present level.

We also have the three university-level colleges of science and technology, Imperial College, Manchester College and Glasgow College. They have between them about 5,000 students of technology. The present policy of the University Grants Committee is to build up these three major colleges, and no doubt they could double their numbers within five to ten years. Imperial College especially is making rapid progress, and as an indication of this has now 40 professors. At the present moment Manchester and Glasgow are lagging far behind, with only 13 and 16 professors according to their latest returns. It seems to be important that for the full development of the potential of Manchester and Glasgow they should be able to expand up to a level of 4,000-5,000, and should become in the course of time fully-fledged technical universities.

If they are to reach the level of M.I.T. in fertility and influence, their resources and staff will need to be greatly increased. At present the average funds available from university sources for research equipment are of an order of magnitude lower than the sums available at M.I.T. and other major United States technological institutions.

Having taken account of the possibilities of expansion of the smaller civic universities, it seems that if we are to increase our university students of technology from 15,000 to about 30,000 over the next decade, there will be room in time for another major college of technology. In view of the probable difficulty of providing sufficient high-quality staff for the university expansion, there is, I think, a good deal to be said for locating it near one of our major government or semi-government research establishments, making use of the immensely expensive research facilities already existing, and also making use of the high quality staff to help in the teaching. A college of this kind should have a very powerful postgraduate school. I believe that this would be more important than developing engineering schools at the new universities, since there is a critical size for a creative graduate school.

The colleges of advanced technology provide another important source of technologists. They cater especially for students who are works-based and who have aptitudes which are more practical and less academic than university students. We now have 4,000 students in the colleges of advanced technology, and they are expected to build up to 14,000 in a few years. I think there is still a great deal to be done to build up the teaching staff, facilities and amenities of the colleges of advanced technology to the level of the universities. The local authorities should be relieved of their administration and perhaps they should in the course of time be brought under the umbrella of the University Grants Committee. The regional technical colleges are also playing an important rôle in providing Dip. Tech.

and Higher National courses for students who can only get one day a week or its equivalent for study, helped out by evening study. The Crowther Report showed that there is a tremendous wastage in the Ordinary National and Higher National courses, only one student in eleven climbing the Ordinary National and Higher National ladder from bottom to top. The reorganization of the courses proposed in the recent White Paper should help to improve matters, but what is really required is a great extension of Day Release, since industries vary very widely in their willingness to grant this.

I must finally say a few words about Churchill College, which has been founded to increase the number of scientists and engineers trained to the highest level, a training which the University of Cambridge has been doing effectively for a long period of time. I was very fortunate myself in being able after an engineering training at Manchester to spend two years in Cambridge studying mathematics in great depth, stretching my abilities to the limit. I hope that Churchill College will provide a similar opportunity for many students in the future. We are planning the college to house 360 undergraduates and 180 postgraduates, together with 60 Fellows. We already have 30 postgraduate students and 20 Fellows, and next October we will have 50 postgraduate students, 70 undergraduate students, and about 30 Fellows in residence; 4 of the Fellows will come from overseas on short-term Fellowships. We aim to have about 70 per cent of our students reading Science and Technology, and the remaining 30 per cent reading Arts. Our first year's students will include 4 Classics, 6 Historians, 3 English students, 2 Law students, 2 Modern Language students and 1 Economist. We consider that it is of great importance to have a substantial proportion of Arts students, since one of the most valuable assets of Cambridge is the general education obtained in the lively discussions in students' rooms, student societies and university clubs. The College will provide the usual facilities for general education, including a Students' Library, a General Library, Lecture Halls, Common Rooms, Music Room, with all our sports grounds on the site. We have already built and are using 20 flats as a nucleus of the College. They will ultimately provide married quarters for Overseas Fellows, young married Fellows, and some married Research Students, so that our community will be less dispersed than most. Our relations with the world outside Cambridge will be greatly helped by our Extraordinary Fellows, of whom Sir Charles Snow and Mr. John Oriel were the first, as well as by our Overseas Fellowships. Our Research Students include three Canadian Athlone Fellows and four other Commonwealth students. This year we have two Overseas Fellows from America, one from Germany, and one from Hungary; next year we will have one from Australia and three from the United States. This diversity is itself of the greatest educational value to our community.

The training of our scientists and technologists for industry must be carried out on a very wide front by providing colleges, universities, colleges of advanced technology and technical colleges to match the very wide range of interest and characteristics of our young people. We have not only to double our provision for such training in the next decade, but we must make the highest level of our training as good as any in the world. To achieve this we shall have to make a great effort.

DISCUSSION

MR. HUGH CLAUSEN, O.B.E., I.S.O., B.SC.(ENG.): Sir John emphasized the great shortage of competent design engineers, capable of translating theoretical work into good sound solid hardware, but the rest of his lecture was almost entirely devoted to scientific matters, and there was little about the training of engineers. My experience has been that engineering is not a science; it is not even an applied science. It is an art, in which the eye, the hand and the brain must work in unison. The exercise of each one of those faculties reacts on, and helps in the development of, the other two.

One of the difficulties that we have suffered from most in the last thirty years or so in engineering development work has been the unwillingness, amounting almost to refusal, of the college graduate type of engineer to get down to a drawing-board in order to bear a hand in the design process. The drawing-board for some reason or other has become the symbol of servitude, whereas the human and intellectual value of the man who can translate the ideas of the scientist into practical form is just as high as that of the scientist himself. The only medium by which he can express his thoughts is the engineer's language—drawing. The college graduate thinks such work is beneath him. Actually in my own view, it is the other way round. It is beyond him; it involves a precision of thought and a clarity of expression which he, having been educated more in generalities, cannot get down to. There is a very serious gap. Industry has not given adequate support to talented men in the engineering design field in the past, and the universities, with few exceptions, have paid very little attention to it. When it comes to engineering work the design department and the drawing office are the womb in which the bright ideas of scientists and others are brought to birth and given the possibility of material existence.

THE LECTURER: I agree. I think one of the problems is how to assist the young design engineer in his early years. Can you do anything to help him besides saying that he must learn on the job? Universities are taking an interest in this problem of the training of design engineers, but I do not think they have come to any conclusions as to how they can go about helping them.

MR. HUGH A. WARREN, M.SC.(ENG.), M.I.C.E., M.I.MECH.E. (Principal, S.E. London Technical College and a Member of Council of the Society): I should like to pay tribute to Sir John's address. Every sentence in it was so interesting to me that I lost the next two! So I have still got two-thirds of the pleasure to come when I read the lecture in the *Journal*.

There is a query that I should like to raise which goes to the very root of the subject, and is closely analogous to the remarks of the last speaker. Talking about engineering education, Sir John said that students should spend something like the first two years on fundamental science and then move on to the technology and of course to practical experience. I thoroughly agree that that is the royal and traditional road, but I am not convinced that it is the *only* one. There are a large number of people, far more in number than the intellectual cream who follow the first road, who eventually get to the fundamental science only because they first learn it 'through their bones' in practical application. There is an analogy in the learning of a language. The old traditional method was to grind at the grammar and perhaps after three years you might arrive at some colloquialisms, such as 'Ou est la plume de ma tante?', or you might not! But the other method is to speak it first and learn the grammar afterwards.

The Institution of Electrical Engineers has recently seen fit to insist on science subjects before the technologies. At first sight it would seem rank heresy to question that, but I think that is because probably all of us who are thinking of these problems here to-day have ourselves come up by the grammar school and university practical road, and therefore the fact that there is, or may be, another road is outside our ken.

But I am more and more convinced that a large number of people would eventually get to the heights in the fundamental sciences if they first approached them in a rather more practical sort of way—perhaps in a way that involves wastage, but only wastage in the sense that not all of them get to the end.

Something of the kind has been attempted by the Ordinary National Certificate and Higher National Certificate route, but that, as I have just said, is tending more and more to become based on science first and technology afterwards. Something of the kind is to be found in Holland, in the chain of the three technical schools (colleges) that start at the craft end, gradually expand and eventually reach a more sophisticated end, including economics and languages. What I am groping at, and what I would like Sir John's advice upon, is whether there is a second road that tends to invert the sequence of science first and technology afterwards?

THE LECTURER: There are many students who, if not good at abstract thinking, not good at mathematics, are good at the more practical things, and they can come to engineering that way. I think the Colleges of Advanced Technology have a great opportunity of having students who do six months in the works and then six months with them over a period of about six years. They deal with these boys who are more practical in outlook and they have a great opportunity to experiment. On the other hand, some of the advanced institutions in the United States are going the other way; they are throwing out of their courses lectures on turbine design, or electrical generator design and so on. They are moving towards having their first three or four years devoted entirely to engineering science, with no engineering.

MR. T. A. WOLSTENHOLME, A.R.AE.S.: Sir John mentioned the extension that would be required in the number of universities to meet apparent and justifiable requirements. I read a report recently that there was a matter of 350 places vacant in technology at close of recruitment last October—250 being in engineering. I wonder what we could do about filling these places. I wonder too whether this was in fact due to a fault in the selection system at the universities, whether it was indeed a fact that boys from school sixth forms were failing to attain the necessary advanced level subjects.

I feel that, due to an increasing lack of residential facilities at the provincial universities, some of their courses are little more than what could be experienced at good technical colleges. I feel that a young man of sixth-form capabilities who is prepared to enter university to complete his education should also be given the opportunity of living in Hall. This is a great experience, I am sure, most valuable to a young person, and certainly should be provided.

THE LECTURER: The vacancies in universities for engineering students have, I think, been in part due to the fact that students apply to some universities only and do not know of the vacancies in others. The universities are now trying to establish a clearing house, which will make sure that where there are vacancies the students will know about them.

There is a strong move now to get more residential facilities in the civic universities. For example, Nottingham has a long-term plan of getting two-thirds of the students into residence, and there are major plans for housing students in Manchester University and Manchester College of Technology. I think you will find that all universities are now pressing for more residential accommodation as soon as they can get the money out of the Treasury.

MR. J. P. MOORE (Battersea College of Technology): Much as I enjoyed Sir John's lecture, he left me with one nagging doubt. Many of the problems of industry are social problems, particularly in the changing world to-day. The young man going into industry to-day is very soon made aware that he has as much to contend with from people as he has from materials and processes. This is where my doubt arose,

because Sir John did not really offer us much to help in this respect. I know it is easy and fashionable in some quarters to talk about humanizing technologists and scientists, but how do you do it? How do you help a young man who comes to you at the age of 19 perhaps from seven years of hot-house education in public or grammar school and university, to be plunged into the realms of industry, where in a matter of days he encounters influences and troubles which will surround him for the rest of his life?

THE LECTURER: I put on a slide showing the results of the study by the Institute of Chemical Engineers, which showed that some of their practising members were spending quite a large part of their time with problems of economics and management. The M.I.T. in America for example does spend quite an appropriate proportion of time on just this kind of problem—I do not know the exact proportion, but certainly at least 10 per cent during a course of four years. I quite agree that the scientist or engineer who is going into industry should have an introduction to these problems. It may be he can only take them up in a serious way in a post-graduate year, or when he is in industry, but at any rate he should be made aware of these extremely important problems.

MR. L. LANDON GOODMAN, B.SC.(ENG.), A.M.I.MECH.E., A.M.I.E.E.: Is it not one of the problems to-day to get more trained engineers on to the production side in industry?

We require production men of very high calibre, men of a calibre equal to those Sir John has enumerated on the research side, and indeed we need production research men of some calibre. In America you have a plant of maybe one or two hundred people employing nearly ten or twelve graduates. Our last reports show that the British Transport Commission, with some 650,000 working people, employs 500 graduates; and it is doing a £1,200 million re-equipment programme. Machine tools have similar treatment in this country. In America, I gather, they have quite large numbers. Is the type of training which Sir John has enumerated to-day going to help us to get these men on to the shop floor? I doubt it. Can Sir John suggest any way of developing a consciousness among these industries of the need for getting men on the shop floor?

THE LECTURER: Well, I think there are at least two ways. The first is that management should have a settled policy in moving their young entrants about. Certainly in the Atomic Energy Authority we found that young scientists came in, and within five years they were moved to management, doing just the kind of job that you were thinking of; they had moved over as they got experience, and I think that is one very good way of taking people who are initially research-minded and moving them over as rapidly as you can during their training period. The other way, I think, is to take the stream of boys who are more practical in outlook and train them in the problems of production. This again the Colleges of Advanced Technology can do.

MR. GOODMAN: My point is that a much higher standard of academic knowledge is required on production matters to-day than in some of the pure research departments with which people are more familiar. I think firms in the field of automation show that some of the mathematical models are extremely complex. I am suggesting that we need both types of man in both departments—on the shop floor and in the design—so that they can talk the same language.

THE LECTURER: Industry has got to do a propaganda job on its new entrants and explain what the opportunities are for the young people as they come in. I think you can persuade quite a lot of them to move over to production, even though they start on the scientific side.

MR. F. M. ARSCOTT, M.SC., PH.D. (Battersea College of Technology): Early in his lecture Sir John mentioned the divergences beginning to appear between

mathematics and physical science. He also said that the number of students of mathematics in the universities is on the whole regrettably low, and that he attributed this largely to the apparent difficulty and nature of the mathematical course. At Battersea we are endeavouring in a sense to take up both these points by having a course which is designed to produce mathematicians for industry—technological mathematicians—and we are finding that we get entrants who are not venturing a course at the university because of the very abstract nature of thought which is required there. We are, however, finding them quite suitable for a practical course, and so are making a small contribution towards filling the gap which Sir John mentioned. My impression, however, is that this is not being done where it ought, ostensibly, to be done, namely at the universities. I wonder if I am right and whether Sir John thinks universities could in fact make a contribution of this sort?

THE LECTURER: I am glad to hear that you are making this contribution. Since we have realized the importance of this problem we are trying to get universities to do something about it, but I do not yet know what the outcome will be. One would hope that they would devise some different kind of course in the future.

MR. C. A. HOGARTH, B.SC., PH.D., F.INST.P. (Brunel College of Technology): I should like to ask Sir John a question about his statement in regard to doubling the number of scientists and technologists over the next decade. It is felt in some quarters that the people who are what is normally regarded as being of Honours standard are mostly being caught in the educational net at the present time. Does this imply that if we do double our numbers we shall double the number of people who are, shall we say, of second-rate quality—the pass degree and Higher National Certificate holders?

THE LECTURER: A number of factors help us. First, the increase in the population, and secondly the undoubted swing of a lot of the best people from arts to science. Certainly this is very pronounced in Oxford and Cambridge, and no doubt in other universities too. The general opinion seems to be that we can just about double the number without lowering the standards too much. On the other hand the Scots, who already have about twice the proportion of children in their universities, think they are scraping the bottom of the barrel.

PROFESSOR F. D. RICHARDSON (Department of Metallurgy, Imperial College): I should like to ask Sir John whether he thinks that our balance between scientists and engineers in this country is not wrong? It is my feeling that quite apart from the question of not having enough of either, our ratio of engineers to scientists is too small; we are expanding our chemistry and physics and pure science departments at universities and colleges as fast as or faster than our engineering departments. I suspect that we are doing this because the bright boys on the science side at school naturally tend to go on studying at university those subjects in which they have done well at school. In addition, too few science masters know enough about engineering to encourage boys to consider this alternative as seriously as they should. If, therefore, we let science departments grow at a rate determined solely by the pressure which is put on them to take boys from school—and this seems to be the present tendency—we are likely to have a ratio of scientists to engineers which does not meet our industrial needs.

In putting this question I should like also to ask Sir John whether our balance here is the same as or different from that found in the United States or in the U.S.S.R.?

THE LECTURER: I think in considering this you have to bear in mind first that industry is now taking a greater proportion of scientists than it used to do in the past, and that the forward plans provide for a greater increase of engineers or technologists than of scientists. So I think it is recognized that we shall probably have a rather greater need for engineers and technologists than for pure scientists. The

third point is that surveys are made about every three years to discover what the requirements of industry are likely to be, and these forecasts are based on how industry thinks its requirements are going to grow: they are not just taken out of the blue, they are based on what industry tells the statisticians. So I would not say that the balance is wrong at the present time.

The Russian output of graduate engineers and graduate scientists is about the same. They are both round about 60,000 or 70,000. In this country it depends on how you count the engineers. If you count university engineers then they amount to about 3,000 every year, whereas the number of scientists is round about 6,000 or 7,000. On the other hand, it is probably not fair to count just the university-trained engineers; you must take account of those from the Colleges of Advanced Technology coming up through Higher Nationals and so on. If you do that then we are not very different from the point of view of balance. It really depends on what labels you put on them.

MR. R. F. MARSHALL, B.SC., A.M.I.MECH.E., A.M.I.E.E. (A.E.I. Ltd.): Recently a conference of science masters was held in industry. The masters were putting questions to some young men in training, and these included a young man who had recently come down from Cambridge (he had had a year in the works before going up to Cambridge and a year just afterwards) and a young man on a thin sandwich course. The young man from Cambridge was asked which he thought was now more vital to him as an engineer, mathematics or English? He said that having now gone through university and come to the works, and being now established as a junior engineer, he experienced a lack of English—a lack of ability to communicate.

This underlines the importance of students gaining a facility in English. I wonder how Sir John would suggest this can be achieved? He has already mentioned the high standard of entrance into Cambridge. Entrance to his own group of colleges is by open scholarship or general examination, the standards of which I know are very, very high. How is it possible for a young man to prepare himself for the high standard of entrance to the university and at the same time make progress with his mother tongue?

THE LECTURER: The university is going to require all entrants to pass a paper on the use of English in the future, and one of the recommendations of the Leverhulme Report on the Education of Scientists was that the number of periods devoted to the teaching of English should be doubled in the sixth form. So there is a good deal of pressure on schools, and the universities at the same time are going to modify their entrance requirements.

MR. G. E. MERCER (Deputy Secretary, Royal Society of Arts): As one who studied at two universities and took an arts degree, I would suggest that the best way in which a scientist can learn to use his own language is to do what all arts students are obliged to do—read the best literature of that language, and thus acquire some facility in it.

MR. HUGH CLAUSEN: The discussion seems to have concentrated on how to bridge the gap between the scientist and the engineer, between the universities and industry. It is a matter which I have been studying very intensively for a long time. I venture to say that the engineering department of Cambridge University is actually a misnomer; it is sailing under false colours, because it does not teach engineering. It teaches the mechanical sciences and does it extremely well, but whether the teaching of the mechanical sciences provides a good foundation for engineering is almost entirely a matter of the character and previous experience of the man concerned.

THE CHAIRMAN: I am sure we could go on discussing this complicated and most interesting question for a very long time, but it is getting late and I think it now only

remains for me on your behalf to thank Sir John for his practical and illuminating address.

This Society is greatly interested in and very jealous for the success of British industry. Many of the biggest firms in the country are closely associated with us. The virtue of this Society is that it is not a specialist body and it takes a wide view. Our founders thought that art should be very closely associated with industry, and we feel the same. I am encouraged by what Sir John has said about the design engineers, that they should study the visual arts, and that this view is generally being taken by him and his college. We must congratulate him on the progress of Churchill College, which I am sure in due course will turn out men who are not merely engineers and scientists, but who are men fitted for life in the widest sense.

The vote of thanks to the Lecturer was carried with acclamation, and the meeting then ended.

APPENDIX

Mr. John B. Francey, A.M.I.E.S., F.S.A.Scot., who was present at the meeting but prevented by lack of time from speaking, has sent the following contribution to the discussion:

In connection with the important question that was raised by the first speaker in the discussion, I have often felt that a better understanding of the practical design considerations affecting manufacture could be gained by a student if a designer from a local company gave some practical design examples to senior students of technical colleges in his area. Such a visit might help to focus much of the basic study undertaken by the student, and introduce him to the techniques applied by design departments, prior to his entering industry. Few graduates—that is, young graduates—realize that a few years spent in a busy drawing office doing design and detail work, and applying a highly trained mind to problems of manufacture, might well be of greater value to their subsequent career than further post-graduate studies.

THE WORK OF THE COMMONWEALTH SOCIETIES

A paper by

THE RT. HONBLE. THE EARL DE LA WARR, P.C., G.B.E.,

Chairman of the Joint Commonwealth Societies' Conference, read to a joint meeting of the Commonwealth Section of the Royal Society of Arts with the Royal Commonwealth Society on Thursday, 27th April, 1961, with Sir Cuthbert Ackroyd, Bt., J.P., LL.D., Chairman, Victoria League, in the Chair

THE CHAIRMAN: It is a privilege for all of us to be present this afternoon in this lovely old building. We are also delighted to have with us Lord De La Warr, a man who has served his country and the Crown in many distinguished offices. We know of his great interest in and work for this great Commonwealth of ours, and we look forward with interest and pleasure to what he has to say.

The following paper was then read.

THE PAPER

It is true to say that at no time in history has the contact between Commonwealth Governments been closer than it is to-day. We all know of the most obvious contacts. We read in our newspapers about conferences between Finance Ministers and Prime Ministers. Perhaps even more important, however, is what we do not read about. There is, for instance, the almost daily exchange of telegrams and memoranda through High Commission Offices, giving each other as a matter of course information that would only in exceptional circumstances be divulged to a foreign nation, however close an ally. In fact, the greater the independence enjoyed by each separate Commonwealth country the greater in some ways the inter-dependence, or at any rate intimacy of contact; and all this without any treaties, or indeed any formal tie whatsoever—perhaps because of it.

If contacts between governments are so close, you may well ask why then bother about the sort of work that can be done by voluntary bodies such as the Commonwealth Societies; and what, in fact, is their function? There are certainly plenty of them. Is there really something for them all to do, and do not at least some of them tread on each other's toes?

It might in fact at first sight seem to justify one in repeating the words of Sir Hilary Blood, used some time ago as a preface to a lecture on a very different subject, when he said: 'Only one thing is perfectly clear—namely if you do not feel thoroughly confused when you consider this subject, then you certainly know very little about it.'

However, the picture when more closely examined is not really quite so confused as it may seem. We have first what we usually speak of as the three major Societies,

The Royal Commonwealth Society, The Victoria League and The Royal Over-Seas League. They all have exactly the same objective, that is to help maintain and strengthen the ties of Commonwealth and to do so by personal contacts and personal relationships, by giving each other a warm welcome when visiting each other's countries and by keeping alive joint memories and traditions through the study of history and of our different ways of life, whilst at the same time making sure that we look at the present and the future as well as the past. On the other hand, each one of these three different Societies has a very different approach to the problem, and for that reason has its own importance and value which, certainly in the larger centres of population, need not, and do not, impinge on those of the others.

The Royal Commonwealth Society is first and foremost a learned Society with a membership of a little over 30,000. Every week some prominent and well informed person is invited to lecture at the Society, generally on a subject of Commonwealth interest. These lectures are open to members of the other Societies and are published in the *Journal* which goes to every member at home and overseas. The Society organizes Summer Schools for the discussion of Commonwealth affairs, and lectures and conferences for sixth-form boys and girls. It sends lecturers and speakers round this country and also overseas. I myself when Chairman went to Canada, Ceylon, Australia, New Zealand and South, Central and East Africa and, for a very short period, to Nigeria. The Society organizes a school essay competition for which many thousands of young people from all over the Commonwealth compete. Its Library, which includes visual aids and films for schools, is the largest in the world on Commonwealth affairs. It has over 350,000 books and pamphlets, and includes gazettes and publications of Empire and Commonwealth Governments. It has attached to it the Commonwealth Information Bureau. The Library is extensively used by students from all over the world, whether or not they are members of the Society.

As a background to all that they are doing on the cultural and educational side, the Society has at its London Headquarters bedrooms, lounges and dining-rooms, which, especially since they were renovated recently, have attracted new members and many of them younger ones.

The Victoria League tackles the problem from a completely different angle. It has a membership of 7,310. Both in London and the provinces it sets out to give individual and personal help to those coming from overseas; and their overseas branches, of course, reciprocate. It arranges for visitors to stay in private houses in various parts of the country, and plans expeditions to all sorts of places of interest. In addition, it makes a considerable contribution to the problem of dealing with Commonwealth students by providing entertainment and parties for them. It also has excellent hostel accommodation for both sexes and all races. The League is, I believe, now very much extending this side of their work by forming area Committees all over London and in other university towns. These Committees get into touch with students, and make them feel at home on a very personal basis. Indeed, a feature of all their work is the intensely personal basis on which it is conducted.

The Royal Over-Seas League provides first-class club facilities for a membership of over 50,000. Indeed, its outstanding contribution is that it is a residential club, always full of friends from overseas. In addition, however, like the Royal Commonwealth Society, it organizes talks, discussions, film shows and an essay competition. It also specializes in encouraging Commonwealth students of music and has monthly concerts given by them. Finally, it organizes an Annual Festival of Commonwealth Music. It has done really splendid work in this direction.

Each one of these Societies has its Branches in provincial cities in this country, and more important, all over the Commonwealth.

This, however, is not the end of the story. If you look in the London Telephone Book you will see that the number of other Commonwealth Societies is legion; but if we limit ourselves to those that are members of the Joint Commonwealth Societies Conference we find that there are societies connected with Malaya, Africa, India, Pakistan and the West Indies. There is also the Commonwealth Day movement. Then, during the last few years, the English Speaking Union has been quite active in a number of Commonwealth countries, and it may well be that the section of it which deals with the Commonwealth will become associated with the other Commonwealth bodies in the near future. They would certainly be very welcome if they would like to do so.

You will see, even from this short sketch of the problem, that there are considerable opportunities for over-lapping and foolish rivalry, if not actual confusion. This was realized some time ago, and as a result of this realization came the Joint Commonwealth Societies Conference to which I have just referred. This body was set up for the express purpose of eliminating over-lapping. Its Chairman is always an ex-Chairman of one of the three major societies.

On the whole it has been fairly successful. There is to-day really very little rivalry and a great deal less over-lapping. When new projects are planned by any one Society, they are brought up at the Conference in order to make sure that it is not already being carried out by anyone else; or if it is already being carried out by someone else, then that there is room for the additional effort, as for instance in helping to deal with overseas students, where the demand is almost infinite. But the prevention of over-lapping is only one aspect of the problem—and a negative aspect at that. What about positive co-operation? Here, I think, we are just beginning to make a little progress. We do organize joint meetings when we are able to get speakers of outstanding importance, and this is being done at least as much overseas as here.

Then there was the agreed memorandum sent out a year or two ago by the Council of each Society to all its branches suggesting ways and means of sharing premises in many towns and cities. I am afraid that not very much has been done as a result of this memorandum, but the fact that it was agreed was in itself important, and at least the beginning of a development that one hopes will one day take place on a serious scale. In Christchurch, New Zealand, one building is run by a joint Committee and used by all Societies, but this, alas, remains the exception rather than the rule.

Another important step was the joint action taken by the three major Societies

in what they did to help the City of London Commonwealth Week last year. The Royal Commonwealth Society organized an Art Exhibition and also a Brains Trust on Commonwealth trade, the Victoria League a dramatic show at the Mermaid Theatre in which young people from all over the Commonwealth took a leading part, and the Royal Over-Seas League a Concert of Commonwealth artists—these were all carried out in the name of the Joint Conference and not of any individual Society.

Finally, on Commonwealth Day, 24th May, in London we shall all be joining together in celebrations with a Service at St. Paul's, and later a luncheon in the Guildhall with Princess Margaret as guest of honour. This will be organized by the Joint Commonwealth Societies Conference, on behalf of all the individual societies.

My own view is that it is hard to exaggerate the importance of the increasing tendency of the three major Societies to work closer together. There are very few cities in the world, except possibly London, large enough to carry three individual Societies working if not competitively, at any rate, separately, for the same cause; at least, not if we really want to have powerful and influential bodies capable of influencing opinion and of keeping alive a feeling for the Commonwealth and what it stands for. It is well worth while, I am sure, to have a rallying point for those who have loved the old Empire and now the Commonwealth; but it is not enough. There are also those who take the Commonwealth for granted or who have forgotten it; and those young people also who have never seen this country or any other country in the Commonwealth except their own. To do this, a powerful, united effort is needed; and not the effort of three small, if not rival societies. Maximum effectiveness on behalf of the Commonwealth must surely be one's aim, and in my view it can only be achieved by much closer working together than is now generally the case.

If this is true of what we may call the old countries of the original white Commonwealth, then it is doubly true of the new independent territories, in which our Societies are all extremely weak. The ultimate test and value of the Commonwealth Societies is the extent to which we are able to gain a foothold in these territories and to have branches there which are really part of the life of the country. Here I would say categorically that united we may possibly succeed in what we are aiming at, but divided we shall most certainly fail. If we do fail it will be a failure in what to-day must be our main function and purpose.

The first test of the modern Commonwealth itself—not only for its own success but for its value to the Free World—is the extent to which it helps to maintain civilized values against the challenge of destructive Communist ideology. This cannot be done by negative means, but by giving proof that peoples of all races, colours and creeds, can make a positive success of a community of free nations. If this is the test of the Commonwealth, then that by which the Commonwealth Societies must be judged is the extent to which they contribute to this end in their own sphere of personal relationships. It is vital, therefore, for the very purpose for which they exist, to have live branches in the new Commonwealth countries. By this word 'live' I mean that they will not succeed in this if they are satisfied with being a comfortable little coterie of Europeans with perhaps a few tame locals as

a gesture; nor indeed, though this is purely my personal view, if they try to tackle the problems as a number of separate, if not actively rival, Societies.

There will be room at the most for only one Society in these countries and that must be based on those who are now responsible for the running of their own countries. This calls for a great deal of new thinking by us all and it must take place soon, if we are not to miss the boat. The tide runs on in human affairs, but unlike the tides of the sea, this one does not roll back, especially in countries that have lately gained their independence. Either we get in now or we never do; so if we mean to do anything about it, the sooner we start the better.

The words multi-racial and non-racial can be a kind of parrot cry which we all periodically utter, but which mean very little in practice. It must be admitted by all our Societies that we still see only a comparatively limited number of coloured faces in our headquarters or branch buildings. This is not entirely our fault, as the colour bar is by no means only one-sided, but this is no reason for our not making the effort to overcome it. Perhaps if there were Malayan, Nigerian and Indian Branches that could dispense hospitality to us, as we do to them, that in itself would be a help, because after all, no one likes always to be on the receiving side.

This brings me to my last point. Have we yet successfully adjusted ourselves to the conception of equal partnership? I refer here not so much to Governments but to ourselves. Are we concentrating our thoughts too much on maintaining contacts as between ourselves at the centre, and each other Commonwealth country?

What about contact between New Zealand and Nigeria, for instance, or Canada, Malaya and Australia, and so on? Some, like Australians and New Zealanders, want to concentrate on what so many of their people still call 'home'. This is something to be encouraged and treasured as of infinite value. But there are others who do not feel that way—or at any rate not to the same extent—and the wider picture of inter-Commonwealth relationships may well mean more to them; thus in Australia I found a strong and growing sense of the importance of their contacts with Malaya and India. To put it quite simply, are we still parents or are we now brothers and sisters? The answer will be different in each case with variations in degree, and not a 100 per cent answer either way in any one case. But it is a question, or series of questions, worth asking and of special importance to the future of our Commonwealth Societies, if we are to become, as we must, an even more effective agency than we are to-day in helping the maintenance and growth of the new Commonwealth of free nations.

DISCUSSION

THE CHAIRMAN: Perhaps I may ask the first question. It is a practical one, as I am a Yorkshireman! With regard to Lord De La Warr's plea for working together in the Commonwealth, how should we finance such a project?

THE LECTURER: At the present moment when branches are set up by any of us in any of the different Commonwealth countries, or indeed in our provinces here, they are really financed by the people setting them up, and the branches then send a contribution to the headquarters. So I would say they finance themselves. But there is no doubt that if we started a joint Commonwealth society in, say, Nigeria,

there arises the question of the rights of the individual members of that society when they come back to London. Are they going to enjoy the privileges afforded them by the Victoria League or the Royal Commonwealth Society or the Royal Over-Seas League or the English Speaking Union? This matter does raise very considerable difficulties of administration, and of differing subscriptions and so on, but I like to take the view that if a certain big objective is right you must pursue it in spite of admittedly considerable administrative difficulties.

MISS ELIZABETH OWEN (Royal Commonwealth Society): On this question of opening up new fields in the new countries: would Lord De La Warr envisage that these would have such a direct connection with this country or would he envisage more of a local autonomy—a sort of federation, not only of Nigeria, but of the Commonwealth Societies in Nigeria; one which would raise its own finances?

THE LECTURER: I think by and large there has got to be local autonomy. When I was Chairman of the Royal Commonwealth Society this was something we did try to press on some of our branches overseas. Unfortunately we were keener on federation in Australia than the Australians were, because Perth, for example, was not very keen to be eaten up by Sydney. There were all sorts of problems like that which we do not take account of here.

Looking at it from the broad point of view, one would hope that the corollary of independence and self-government in regard to political life would be the greater independence of the branches overseas; and they could only achieve that by themselves federating on their own national basis.

MR. J. B. HODGSON: If the Commonwealth and the Commonwealth Societies mean anything, should not the Societies speak up on questions such as the entry into Australia of other members of the Commonwealth, or on an issue such as South-West Africa? You mentioned, Sir, the difficulty of getting people from amongst the new members of the Commonwealth to join the Societies; surely what I am suggesting should help to remedy this situation?

THE LECTURER: You have two points. One is the merits of the question, and the other is whether either the Commonwealth itself, or the Commonwealth Societies, are going to survive or thrive by interfering in each other's affairs. I personally take the very strong view that once we start telling Australia, for example, what to do about people from Hong Kong, or Ghana what it is to do with its own opposition, we are going to get into an unholy mess. Let us all as societies look after our own affairs, and simply maintain personal links and the closest possible tie! At one time there was tremendous pressure for the Royal Commonwealth Society to interfere on one side or the other in East Africa. I held that we might all have individual views and take individual action in our own spheres, but that as members of the Society we were non-political, dealing in personal relations between individuals.

MR. NORVAL ROY PERRY, J.P. (Australia): I was a little disconcerted by the recent announcement of Mr. Verwoerd during the late Prime Ministers' Conference that if South Africa withdraws from the Commonwealth there would in the immediate future be a general disintegration of Commonwealth relations. Would the Lecturer agree with that statement?

THE LECTURER: I would not. I expect all of us in this room have different views about the tragedy of South Africa. Whatever view we take as to the rights or the wrongs of the particular policy, we must all feel that it is a terrible tragedy when we think of the thousands of British people there who, we know, still love this country. But I do not feel that it need mean in any way a break-up of the Commonwealth. I should say that we have not necessarily seen the end of the whole South African story yet. I certainly hope not.

MRS. A. V. BOWEN (Hon. Secretary, S.S.A.F.A.): I am concerned about social welfare in these countries, and in this respect I should like to feel that priority was given to the countries such as Ghana where I should like to see the social side developed. My mind goes to Canada, where we have wonderful contact with the Imperial Order of Daughters of the Empire. If only we could create something similar elsewhere, get the faith that we need, drag out the fear that is between us, and go for social welfare.

THE LECTURER: On the whole the Societies have not yet developed that welfare side very strongly. It may well be something to be extended. The Victoria League has very close contacts with the Imperial Order of Daughters of the Empire, in fact I think the I.O.D.E. in Canada is almost a sister organization. They do wonderful work.

SQUADRON-LEADER N. DENYER GREEN: I wonder if Lord De La Warr would like to comment on a possible amalgamation, which would give greater strength to the three Societies with parallel aims. I am thinking especially of the smaller places overseas; it is very confusing when there are perhaps three different headquarters.

THE LECTURER: We have got to recognize that there are certain things like traditions and special loyalties, particularly with voluntary organizations, which cannot be ignored. I myself see advantages in getting closer and closer together, and if the Societies all happily came together I think they would be more effective—in theory. But if it meant losing the devoted service of a lot of individuals who quite voluntarily give themselves to a certain cause, then of course we might do more harm than good. I personally feel that we should tackle the question positively rather than negatively: by tackling new activities together and thus getting used to each other's ways.

I should frankly like to see a great deal more done now in the sharing of premises. I felt exactly as you did when I went to places like Perth and Adelaide, and to places in New Zealand, where I saw three not terribly effective Societies, their resources all divided, some in semi-adequate premises, some in inadequate premises and some without premises at all. If they only would get together (even retaining their individuality) and share one good building, I am sure it would be for the good. But that has got to come by positive projects. You cannot force this thing.

THE CHAIRMAN: Further to that question, Lord De La Warr addressed a conference of the Victoria League last week. It is our Diamond Jubilee Year, and we had sixty-five delegates. They were very impressed with what he said about co-operation, but very determined on co-operation and not amalgamation. In the case of the Victoria League there have been three generations of people loyal to the Commonwealth in a particular way, and though of course they realize that they must co-operate for strength, yet at the same time they will maintain their loyalty to their old associations.

SQUADRON-LEADER DENYER GREEN: I wonder whether there is any possibility of a membership at a slightly increased subscription which would allow one member to go to the headquarters of other Societies, thus getting to know others better?

THE CHAIRMAN: That is a very good suggestion.

THE LECTURER: A very interesting idea. I will make a note of it.

MR. DONALD J. FINLEY (Australia House): We have heard recently that there is to be a Commonwealth Festival of Arts in 1963. May I ask what part—it cannot of course be said very definitely yet—each Society is taking in this? I should like to feel that they will be taking part in it. Also, does the speaker feel that at some later date we should have a large conference centre in which all the Commonwealth countries could meet? One big building or centre where, every day, we can display Commonwealth arts and hear Commonwealth music and opera, and so on.

THE LECTURER: The idea of one central building seems very attractive, but the great problem about these shows is to keep them alive. I have a feeling that going around the Commonwealth might be the best way of really making this festival a really live show, like the Commonwealth Games. The Societies have certain personal contacts with the Commonwealth Arts Festival. I, myself, am on the Committee and so I think are other members of the leading Societies.

MR. OSWALD P. MILNE, F.R.I.B.A., J.P. (Chairman of Council, Royal Society of Arts): I am sure that the Commonwealth Societies are doing a great deal for overseas students in this country. The more that can be done for them the better. May I ask whether use is being made of the Rotary Clubs throughout the country for that purpose? Rotary Clubs are always wanting to find worthy objects and some of them do entertain students in their areas from all over the world, and make entertainments for them. I wonder whether that could be developed more throughout the country, particularly in the towns where there are universities?

THE LECTURER: I think the Rotary Clubs are playing a part in this, as they are playing a useful part in so many things. As you know, the organization for dealing with students is at the British Council, with Sir John Macpherson as Chairman, and a great number of organizations are involved. I am not sure whether Rotary Clubs are actually represented on that body, but they are certainly doing a great deal of work.

Work for students is one of the few spheres in the Commonwealth where there can never be overlapping. I was told the other day that there are no less than 50,000 students in this country at any one time, the vast majority of them from the Commonwealth.

SIR HAROLD SHOOBERT, C.I.E., E.D. (Hon. Secretary, The Pakistan Society): May I refer again to the question of amalgamation? It has been my own privilege to be fairly closely associated with all the three big Societies. If there was amalgamation, even at the present stage there would be over one hundred thousand members of this single organization and it would become extremely difficult to manage it in the present very personal and friendly way. It seems to me that co-ordination is a much better idea. People like to have their own personal 'homes', and that is a strong argument for keeping things as they are. Even in our rather small Pakistan Society, when we had four or five hundred members one used to be able to know almost every member individually, whether British or Pakistani, but now we have grown to nearly one thousand it is getting difficult to recognize everybody. The personal touch is very important.

MRS. SUSAN POTTER: I should like to see one day set apart on which members of the three Societies could meet together with not too much state. Can we not organize some function in a large building where we can all get together for a conference, and a social evening afterwards? We could thereby get to understand each other's outlook and the work all are doing.

THE LECTURER: Yes, but if you have anywhere big enough for us all to meet then it is going to be frightfully impersonal: we would all have our little sections and get together and talk to the people we know. One place where you never get to know anybody is at a really large reception, isn't it?

MISS OWEN: The younger members of the Societies do meet fairly regularly at present. The junior committees have certainly been meeting in the Royal Commonwealth Society's building at joint receptions in the evening, swopping ideas. This has been going on for some time.

THE CHAIRMAN: On your behalf as well as my own I should like to express our very warm thanks to Lord De La Warr for his most interesting address. To sum it up, we should perhaps follow the dictates of St. Paul, who said, 'All ye are members

one of another. Our main object is friendship within the Commonwealth, and I think that it is the spirit of the work which matters, and for which organizations exist. We are all working for the same end, and I am sure that meetings of this nature help us and I think help everyone to do something to interest other people in the work of the Societies, and our Commonwealth. I should also like to express our gratitude to the Chairman of the Commonwealth Section Committee, Royal Society of Arts, for inviting us to meet in this charming and historic hall to-day.

The vote of thanks to the Lecturer was carried with acclamation.

MR. OSWALD P. MILNE: I am privileged on your behalf to thank Sir Cuthbert Ackroyd for presiding at this meeting. We are particularly pleased to-day to have the Chairman of the Victoria League, which is doing wonderful personal work. My wife is a member of the League, and through their efficient organization we welcome to our home once a month members of the Commonwealth, and it is very clear to us that they do value being invited to an English home. You can imagine that when a man or woman from overseas who has looked forward to coming here finds, when he or she arrives in England, that nobody takes the slightest notice of him or her, it is very flat; the Victoria League tries to fill that gap, and in doing so produces the most excellent relations between this country and the Commonwealth.

The vote of thanks to the Chairman was carried with acclamation, and the meeting then ended.

GENERAL NOTES

REGULATION OF THE NUMBER OF CASTS OF A SCULPTURE

The President and Council of the Royal Society of British Sculptors have issued a statement explaining the inauguration of a new Certificate of Authenticity for casts of Sculpture, which they are now in a position to issue. The Certificate, which guarantees a limited number of casts of any one work by a living sculptor, is designed to enable the collector or gallery curator who is buying a modern bronze to establish whether it is a unique object or one of a series of exactly similar casts. Hitherto, the statement explains, such certainty has not been possible. The improvements which have taken place in the techniques of bronze founders in modern times have greatly facilitated and increased the production of replicas, and there has been no sure way of differentiating between them, nor any standard, generally accepted, method of control.

It is emphasized that in the new policy of the Royal Society of British Sculptors there is no intention to hinder the production of good replicas of modern sculptures; the rule is that each member artist shall decide for himself the total number of casts of a particular work to be made, and, having so decided, shall inscribe each cast with his signature and its serial number within the total number of casts comprising the 'edition'. These facts are then more fully stated, and guaranteed, on the Certificate. The Society hopes that this standard of conduct laid down for its own members will come to be universally observed. The issue of the Certificates will be automatic for any casts supplied by members of the R.B.S., and the Society is also prepared to extend this service to any professional sculptor who, although not a member, cares to apply for it.

Copies of the statement referred to, which includes a facsimile of the Certificate, may be obtained from the Secretary of the R.B.S. at 6 Queen Square, London, W.C.1.

NEW AWARD IN INDUSTRIAL DESIGN (ENGINEERING)

The Leverhulme Trustees, in consultation with the Council of Industrial Design and the Society of Industrial Artists, have instituted an annual award for industrial

design. The award will be open to students at art schools and colleges in Great Britain who are engaged in full time courses leading to a recognized diploma in industrial design (engineering). Each school providing such courses will be asked to submit to an adjudicating panel the work of one final year student, including two design projects carried to a reasonable stage of completion, and from these submissions a selection will be made. The first award, to the value of £500, will be made in 1962, and is intended to be used for study in Europe for a period of not less than ten months.

STUDIES IN THE SOCIETY'S ARCHIVES XX

The Society of Arts and the Committee of the Privy Council for Trade, 1786–1815 (iii)*

The Trade in Goat Skins, 1791

In April, 1791, William Blake, a merchant member of the Society, petitioned the Lords of the Committee for Trade for a prohibition on the importation of tanned goat skins from Portugal, which he hoped would make the Portuguese Government reconsider their own ban on the export of raw goat skins.[1] Blake imported raw goat skins in order to manufacture red leather of a fine quality and, in 1773 and 1774, he had received awards from the Society for producing red leather 'equal to the best Lisbon or Morocco'.[2] The Committee asked for copies of the Society's proceedings in the matter and these were read at a meeting held on 5th May, when counter-petitions, from manufacturers who made use of the prepared material, were also read. The Committee came to the conclusion that the best course was to increase the duty on imported tanned goat skins, and to renew the law making imported raw goat skins free from duty.[3]

Jamaican Cinnamon, 1792

On 5th January, 1792, the Committee took notice of 'Information . . . from Mr. More, Secretary to the Society for the encouragement of Arts and Manufactures, that a specimen of Cinnamon produced in His Majesty's West India Islands had been received by the said Society'. It ordered that a letter should be written to More asking for a sample and 'a Copy of the proceedings of the said Society respecting such Cinnamon'.[4] Since 1790 the Society had offered an annual premium for the greatest quantity of British West Indian cinnamon imported into the port of London. The cinnamon had to be 'equal in goodness' to that produced in the East Indies—the traditional source of the product—and the minimum quantity for consideration for the reward was 20 lb.[5] The premium was not claimed, but Thomas Dancer, the Director of the Botanic Garden of Jamaica, sent samples of cinnamon to the Society which found great favour amongst 'some of the most eminent dealers in that spice'.[6] When the Committee had examined one of these samples and received an account of the Society's work, it decided that applications for the premiums were probably hindered by the law which limited the amount of cinnamon imported from places other than the East Indies to bales of 70 lb. or more.[7] No change in the law, however, would seem to have resulted from this decision.[8] Later in the year the Committee agreed to obtain for the Society copies of the Acts of the Jamaican Assembly relating to cinnamon.[9]

The Proposed Botanic Garden in the Bahamas, 1793

The Committee also endeavoured to assist the Society in its unsuccessful attempt to establish a botanic garden in the Bahamas.[10] The matter was reported to the Committee on 26th June, 1793,[11] when it was agreed that the Secretary of State, Henry Dundas,[12] should be advised to communicate the Society's proposal to the Bahaman legislature.[13]

* Parts (i) and (ii) of this Study appeared in the issues of the *Journal* for April and July respectively.

The Board of Trade, c. 1810 (*from Ackermann's* Microcosm of London)

Black Lead Melting Pots, 1796

On 16th February, 1796, the Committee received a petition asking for the reduction of the duty on imported black lead.[14] This material was used for the manufacture of assaying crucibles or 'melting pots' as they were called, and the petitioner, Johanna Hempel, owned a melting-pot factory which suffered not only from the duty on the raw material but from the competition of completed foreign melting pots. Johanna was the widow of C. J. Hempel, who in 1775 had received a premium of £30 from the Society.[15] Their Lordships decided therefore to ask the advice of the Society, 'who appear to have interested themselves in the above mentioned Manufacture'.[16] The Society referred the matter to its committee of chemistry who, in their turn, approached three experts, including the Assay Master of the Mint, to obtain their opinions of the relative merits of English and Foreign lead pots.[17] The Society's committee took note of their opinions, which were in favour of the general use of English lead pots and of reserving foreign ones for melting exceptionally large quantities of metals, on 26th February, 1796.[18] The Minutes of this meeting were considered by the Lords on 21st March, together with a letter from Samuel More, on behalf of the Society. More admitted that Hempel's manufacture had not succeeded 'as well as was wished and expected, in consequence of the Encouragement and premium given by the Society for that purpose. The failure [he continued] seems entirely owing to the high price of the Black Lead employed in their composition'. He nevertheless urged the Committee not to make the duty on foreign melting pots too high in case consumers are 'put too much in the power of the manufacturers'.[19] On 6th April, 1796, the Committee of the Privy Council for Trade duly recommended to the Treasury Commissioners "That it may be advisable that the Duty

upon Foreign Black Lead, imported into this country, which is now 6*s* 8*d* per cwt., should be reduced to 1*s* per cwt., and that one moiety thereof should be drawn back upon re-exportation'.[20] The recommendation became the law of the land on 14th May, when an Act which aimed at 'the more effectual preserving and encouraging the Manufacture of Black Lead Melting Pots' received the Royal Assent.[21]

Crushed Rock Salt, 1805–6

On 17th December, 1805, the Committee of the Privy Council for Trade referred to the Society a petition for the removal of duty upon rock salt from Messrs. Swinton, Blease & Co., salt proprietors, of Northwich in Cheshire. The petitioners claimed to have developed a method of crushing rock salt so that it became as fine as foreign bay salt and they accompanied their petition with a sample and a chemical report which alleged that crushed rock salt could be used for preserving fish.[22] The Society's committee for chemistry, at a meeting on 15th February, 1806, found that the sample was 'a selected Specimen, and that Rock Salt of such Quality can hardly be expected to be obtained from the Mines of Great Britain in large Quantities; but even if plenty of it could be procured the Committee doubt whether from the great Quantity of brown and less transparent Rock Salt contained in the Specimen, it would be equal to the Salt now used.'[23] The Lords of Trade were not satisfied with this verdict and on 10th April they wrote to Charles Taylor, at this date Secretary of the Society, asking for fuller details of the experiments conducted by the committee of chemistry.[24] After conducting a lengthy re-examination of the matter on 17th May, the committee still felt 'themselves fully justified in their former Report on the Subject and still believed that Rock Salt of the Quality sent to the Rt. Honble. the Lords of the Committee of Council by Messrs. Swinton, Blease & Co. cannot be obtained in any considerable Quantity from the salt mines of the United Kingdom'.[25] The Lords, however, who had consulted with other experts, including Dr. James Jeffrey of the University of Glasgow, persisted in the view that the sale of crushed rock salt should be encouraged.[26]

A Sicilian Corn Mill, 1812

In July, 1812, the Committee offered to present to the Society a model of a corn mill which had been sent to it by the British Consul in Sicily.[27] After he had learnt that the model did 'not exceed the Dimensions of the Models now admitted in the Collection of the Society for Arts',[28] Charles Taylor agreed to accept it and their Lordships 'Ordered that the said Model be sent to the Society of Arts in order that the same may be deposited among the Models belonging to that Society'.[29]

G. O. Needham's Carding Machine, 1815

In February, 1815, the Society had reached a favourable conclusion as to the merits of an improved carding machine invented by G. O. Needham. The financial straits of the inventor had induced them to give him a £20 advance on the £40 bounty which they had voted him.[30] In March, the matter came before the Committee for Trade, and they obtained for him a government bounty of £100.[31] The Committee seems to have felt that the House of Commons would have been a more fruitful source of aid to the inventor: 'If more extended relief be desired for Mr. Needham', they wrote to the Society, 'their Lordships cannot avoid again suggesting that a proposition to that effect would be . . . favourably received by the House of Commons.'[32]

(*To be concluded*) D. G. C. A.

1. B.M. Add. MSS. 38226, f. 129. Letter from William Blake to Lord Hawkesbury, 16th April, 1791.
2. *Register of Premiums and Bounties given by the Society* . . . (London, 1778), p. 21.
3. L.A., C3/143. S. Cottrell, 1791; Soc. Min., 20th April, 1791; BT5/7, 5th May, 1791; 31 George III, c. 43.

4. BT5/7, 5th Jan., 1792; Soc. Min., 11th Jan., 1792.
5. *Transactions*, Vol. VII (1789), pp. 334–5.
6. Ibid., Vol. X (1792), pp. 256–8.
7. BT5/7, loc. cit.
8. The Act 6 George I, c. 21, forbade the importation of species 'in Bags and other small parcels'.
9. BT5/8 & BT3/4, 15th Nov., 1792.
10. Sir H. T. Wood, *The History of the Royal Society of Arts*, p. 100.
11. BT5/9, 26th June, 1793.
12. Dundas had been a member of the Committee of the Privy Council for Trade since 1784.
13. L.A., C5/6. W. Fawkener, 1793; Soc. Min., 23rd Oct., 1793.
14. BT5/10, 16th Feb., 1796.
15. MS. Transactions, 1774–5, p. 60.
16. BT5/10, loc. cit.
17. Soc. Min., 17th Feb., 1796; Min. Comm., Chemistry, 19th Feb., 1796.
18. Min. Comm., Chemistry, 26th Feb., 1796.
19. BT5/10, 21st March, 1796.
20. Ibid., 6th April, 1796.
21. *Journals of the House of Lords*, Vol. XL, p. 741; 36 George III, c. 79.
22. BT5/15, 17th Dec., 1805; L.A., B8/68. S. Cottrell, 1805; Soc. Min., 18th Dec., 1805.
23. Min. Comm., Chemistry, 15th Feb., 1805.
24. BT5/15, 13th Jan., 1806 ; BT5/16. 10th April, 1806; L.A., B8/70. S. Cottrell, 1806; Soc. Min., 16th April, 1806.
25. Min. Comm., Chemistry, 17th May, 1806.
26. BT5/16, 18th July, 1806 ; L. A. B8/69. J. Jeffrey, 1805; A. & N. Clow, *The Chemical Revolution*, p. 560.
27. BT5/21, 29th July, 1812; L.A., B1/253. T. Lack, 1812.
28. L.A., B2/288. T. Lack, 1812.
29. BT5/21, 19th Aug., 1812; L.A., B2/254. T. Lack, 1812.
30. Soc. Min., 1st, 8th and 15th Feb., 1815.
31. BT5/25, 1st March, 1815; Soc. Min., 8th March, 1815.
32. BT5/25, 12th June, 1815; Soc. Min., 14th June, 1815; BT5/25, 17th June, 1815.

OBITUARY

We record with regret the death of a former Vice-President, and four Fellows, of the Society.

LORD MCGOWAN

Lord McGowan of Ardeer, K.B.E., D.C.L., LL.D., who died in London on 14th July, aged 88, was Honorary President of Imperial Chemical Industies Ltd., and for twenty years its Chairman. He was a Vice-President of this Society from 1930–2 and again from 1951–2, and had been a Fellow since 1929.

At the age of 14 Harry Duncan McGowan started work as a clerk in Nobel's Explosives Company, Glasgow, and by the early years of this century he had risen to be managing director and begun his long and fruitful series of visits to the dominions and foreign countries. Those to Canada resulted, in 1910, through his contrivance, in the merger of a number of major companies to become Canadian Explosives Ltd. In 1918 McGowan was the prime mover in a merger within the British explosives industry from which emerged Nobel Industries Ltd. A further important combination due to his foresight and skill in negotiation took place in South Africa in 1924, when Nobel joined with Cape Explosives Works to form what

is now African Explosives and Chemical Industries. Two years later McGowan, together with Sir Alfred Mond, brought into being the largest industrial chemical group ever seen in this country—Imperial Chemical Industries Ltd.—by arranging the amalgamation of the British Dyestuffs Corporation, Brunner Mond, Nobel Industries and the United Alkali Company. In terms of the national interest, the significance of this great union can hardly be overstressed, and it is McGowan's memorial. He was President and Deputy Chairman of I.C.I. from its inception, and succeeded Lord Melchett (as Sir Alfred Mond had become) in the chair in 1930. He retired in 1950. He was thus in control of the enterprise during both the formative pre-war years and the aftermath of war.

McGowan was appointed K.B.E. in 1918, and made a baron in 1937. He was President of the Society of Chemical Industry in 1931, and received honorary degrees from several universities in England and Scotland. In addition to his business responsibilities, from 1943 onwards he devoted much time to the affairs of St. Mary's Hospital, being successively a member of the board of management and a governor.

Lord McGowan appeared before this Society as the Trueman Wood Lecturer in January, 1951. His subject, 'A Century of British Industry 1851–1951' (*Journal*, Vol. XCIX, p. 235), was one on which he spoke with special authority and conviction.

MR. GUY CHIPPERFIELD

Mr. Guy Chipperfield, C.B.E., who died on 26th July, aged 67, played a leading part in the development of the seed crushing industry, and was recently re-elected President of the International Association of Seed Crushers for the eleventh year in succession. He had been associated, in various capacities, with the firm of Unilever since 1921, when he joined what was then Lever Brothers Ltd., at Port Sunlight. An accomplished linguist, and educated partly on the continent, Chipperfield was closely concerned with the direction of Unilever's European affairs, and more particularly, during the 1930s, with its interests in Switzerland and Hungary. In 1939 he became a member of the Unilever, United Kingdom Oil Mills Executive. He was appointed Chairman of British Oil and Cake Mills Ltd. in 1948.

Chipperfield was made C.B.E. in 1955. In December, 1953, he took the chair at a meeting of the Society when Dr. E. G. Woodroofe read a paper on 'The Seed Crushing Industry' (*Journal*, Vol. CII, p. 77). He was elected a Fellow in 1955.

DR. G. C. J. DALTON

Dr. George Clifford James Dalton, B.Sc., B.E., Ph.D., Director of the Australian Atomic Energy Commission's nuclear research establishment at Sydney, died on 17th July, aged 45. He was educated in Auckland, New Zealand, at the grammar school and university, and at Oxford, where he was a Rhodes Scholar. He served in the Technical branch of the R.A.F. from 1941–5, and after the war joined the atomic research staff at Harwell for two years. In 1949 he returned to the University of Auckland as Professor of Mechanical Engineering and Dean of the Faculty of Engineering, posts which he held until his appointment as Chief Engineer to the Australian Atomic Energy Commission in 1955. Dalton, who received his final promotion only last year, had for long contended with a serious physical disability caused by an attack of poliomyelitis at the age of 20. It is the measure of his courage and determination that in spite of his handicap he won both full success in his career and attention as an oarsman and Rugby footballer.

Dr. Dalton was elected a Fellow of the Society in 1954.

DR. OTTO MAASS

Dr. Otto Maass, C.B.E., F.R.S., F.R.S.C., the distinguished Canadian scientist and teacher, died in Montreal on 2nd July, aged 71. Brought to Canada from the

U.S.A. as a child, Maass received his education at the Universities of McGill, Harvard and Berlin. He returned to McGill in 1923 as Macdonald Professor of Physical Chemistry, and subsequently became Chairman of that Department. In addition to his teaching and research work at the University he was for many years associated with the Pulp and Paper Research Institute of Canada, and was its General Director from 1940 to 1955, in which year he retired from his posts at McGill and accepted the appointment of principal research officer to the National Research Council's Division of Chemistry.

During the Second World War Maass undertook work of great importance to Canada and the Allied cause, notably as Director of Chemical Warfare and Smoke in the Department of National Defence, which he continued to serve for several years after the conclusion of hostilities as scientific adviser to the Chief of General Staff. He was adviser on special weapons to the Chiefs of General Staff until 1957.

Dr. Maass was elected a Fellow of this Society in 1953.

PROFESSOR K. J. SCOTT

Professor Kenneth John Scott, M.A., LL.B., D.P.A., who last year was appointed Head of Victoria University of Wellington's School of Political Science and Public Administration, died in New Zealand on 19th July, aged 48. Only a week before his death he had the distinction of being appointed to the Royal Commission of Inquiry into the Public Service.

Scott was himself a graduate of the former Victoria University College, where he had a notable career and was nominated for a Rhodes scholarship. From 1941–5 he was Senior Clerk to the Navy, and after a period with the Public Service Commission returned to Victoria as Senior Lecturer in Political Science in 1946. Ten years later he was appointed Associate Professor. Scott spent a year at Oxford as Nuffield Fellow in 1950–1, and was elected President of the New Zealand Institute of Public Administration in 1958. Early in that year he contributed a most able paper on 'New Zealand's Political Traditions' (*Journal*, Vol. CVI, p. 354) to the Proceedings of this Society, of which he became a Fellow in 1959.

NOTES ON BOOKS

LONDON THE UNIQUE CITY. *By Steen Eiler Rasmussen. Harmondsworth, Penguin Books, 1960. 5s net*

This volume is a most welcome reprint (abridged only in the positive sense that it is shorn of a number of chapters which had to a large extent become out of date) of a brilliant study of London architecture which was made in the 'twenties by a young Danish architect, and is already a classic in its field. Like most really penetrating historical work, Dr. Rasmussen's book on London sprang from a passionate concern for the problems of the present. Faced with much that was ugly and ill-adapted to human needs in the Continental cities of the early twentieth century—tall, bleak tenement buildings, overcrowded central areas, a scarcity of trees and parks, faulty systems of communication—he found in London something which seemed just short of a miracle, the most heavily populated of all European cities, yet one which appeared to have escaped the domination of these evils. To him, London was the 'unique' city, unique because of its 'scattered' growth: its laws of development had compelled expansion outwards instead of upwards. What were these laws of development? The answers might prove of the utmost value to modern town planners.

In search of the answers to this question, Rasmussen came to London regularly every year, usually for a month at a time, reading in libraries, seeing how Londoners lived and behaved, and exploring in turn every district of the city, camera in hand—

most of the photographs in this book are his own, and reveal his humane Danish eye for the picturesque and the domestic. He saw how the foundations of the modern city were laid by the very smallness of the area encompassed by the old Roman walls, which compelled free development without. He found the characteristically English dislike of flats reflected as early as the sixteenth century in Elizabethan decrees against overcrowding which laid down the principle of one family, one house. He discovered that the London squares, which derived historically from the example of Henry IV's Paris, had in fact nothing in common with the ideals of baroque town planners and that each formed 'a restricted whole as complete as the courtyard of a convent', closely similar to the quiet and peaceful enclaves of the Inns of Court. Thus he perceived rightly in the rejection of Wren's plan for the rebuilding of London after the Great Fire a 'triumph for what might be called the idea of London'. Everywhere he noted the victory of common sense. The rich and the great lived in plain terrace houses, with no show on the outside, but with interiors most ingeniously adapted to the requirements of everyday life. Rasmussen is at his best in his perceptive and witty comment on the London house.

Perhaps most important, he recognized how large a part had been played in the development of London by the English love of sports and country life, and he gives this great emphasis. He devotes whole chapters to the subjects of recreation grounds, the English landscape garden, and the London parks, and a separate one to what he calls 'the true and sad story of the Regent's street', Nash's Royal mile joining Carlton House to Regent's Park, which brought the amenities of the country right into the heart of the metropolis. He shows how Londoners have always been jealous of their rights to the traditional recreation grounds as far back as the Middle Ages, and how, in Victorian times, the number of parks was increased to keep pace with the mushroom growth of the city, whilst in Paris during the same period the number actually declined. The parks are by no means all beautiful, but they are places where people could enjoy themselves in the way they wanted. This he approves: speaking of Hampstead Heath, he says that 'we have in the middle of the great city an instance of the right preservation of Nature—*human nature*'. We can see here the sympathy between the Danish and the English temperament.

As a social study of London architecture, Rasmussen's work is every bit as valid to-day as it was in the 'twenties and 'thirties, and as a book of outstanding perception and clarity of treatment, it deserves a special place on the shelf with masterpieces such as Sir John Summerson's *Georgian London*.

JOHN HAYES

MASTERPIECES OF GREEK ART. *By Raymond V. Schoder. London, Studio Books,* n.d. 70*s*

In many ways *Masterpieces of Greek Art* is a remarkable book—a labour of devotion obviously—offering the reflections and judgements of one who has immersed himself deeply in Greek thought, and felt keenly the challenge of the Greek way of life. His book is a personal anthology of beautiful things depicted in 97 exemplary colour plates covering an extremely wide range of artefacts and monuments, from millefiori glass to the Parthenon. The author, during years of extensive travel has made a series of colour transparencies of unique quality. This book then displays the author's choice taken from the author's point of view with his own lucid, explanatory and enriching commentary—a book that approximates as nearly as any book can to the ideal.

The Greeks loved beauty, perceiving it with pristine clarity. Possibly the climate had something to do with it. At any rate the Greeks always preferred to depict things in their most vivid, characteristic and permanent forms. That is why they used silhouette and profile so extensively for depicting shapes upon flat surfaces; why also, perhaps, they took great care always to articulate clearly the muscular architecture of the human torso in their sculptures. 'They approached beauty with awe

and delight, as a thing man is most meant for', and, in the finest period, invariably revealed beauty stripped of empty show, glorying in its naked strength, order and perfection. One of the most astonishing things is that Greek concepts of beauty still shine through the translations of later and much less sensitive copies.

The uniqueness of Greek art lies in the creative integration of factors common to works of art in all periods, with others of a special geographic and ethnic character. Moreover the value attached by the Greeks to human qualities, to symmetry, to lucidly defined forms and to subtle refinements, resulted in a form of art that makes its appeal directly to the mind. Greek art is entirely rational and intellectually satisfying.

Dr. Schoder's prefatory essay unfolds the story of the development of Greek art from the Mycenaean age until 'the fire went out at the end of the second century after Christ', and in a final passage attempts to assess the relevance of Greek art to the twentieth century. 'Rational comprehension of intrinsic pattern, proportion, symmetry, the intelligible form radiant in its clarity and meaningfulness', he persuades us, are as essential to our own age as to the Greeks 2,500 years ago, not merely because Greek ideas were, and still are, such a potent factor in shaping European culture, but also because we also crave for order, intelligence, meaning, and would, if we could, discern the pattern of relationship between ourselves and the Universe. It is some satisfaction to know that others, long past, when civilization was still young, using the human form as its means, discovered such a pattern in art.

It is difficult to comment upon the lovely things reproduced so beautifully in this book. Some, like the Winged Victory of Samothrace, are familiar: others make a more vital impact because they have been less frequently illustrated. Such for example are the finely characterized Lysimachus of Thrace and the notable sculptures of a Roman man (plate 85) and girl (plate 95). A specially delightful illustration is the honey-coloured Proto-Attic amphora from Eleusis (plate 8) decorated with the two Gorgons, Stheno and Euryale, drawn in a convention that would not seem amiss, as the author points out, in the pictures of Braque. Another plate which shows how modern the ancients were, is the portrait of a girl on a mummy case from Fayum (plate 93), with her dark lustrous eyes and cerese lipstick. The pretty Tanagra figurines seem perhaps a little out of place in such vivid, lively company.

There is little to criticize except the repetition of the error common to nearly all classical studies, the use of the word 'glaze' for the black ceramic pigment used in Greek vase-painting, and the misleading phrase 'compound like porcelain' in the author's comment upon plate 58. The Greeks certainly never produced any substance comparable to porcelain. These are small blemishes in this well-planned and finely printed book. The author concludes his 'private art gallery with speaking guide' with an excellent chart summarizing the principal events in Greek and Roman history and representative examples of architecture, art and literature, and a select bibliography.

REGINALD G. HAGGAR

PRIMITIVE INTO PAINTER: LIFE AND LETTERS OF JOHN TOOLE. *By William B. O'Neal. Charlottesville, University of Virginia Press, 1960. 10 dollars*

With something like the English recognition of the artistic and social significance of Hogarth and his struggling associates—with like pride, only with deeper piety—does America revere her itinerant painters of the early nineteenth century. As the new civilization moved westward, many painters travelled with the first explorers and migrations, recording the land, the people, the drama of a nation on the march. 'Pioneers, O Pioneers', exulted Walt Whitman.

John Toole was one of these journeymen pioneers of portraiture, landscape, and historical painting—a rapid worker with a more expressive touch than that common to the majority of these so-called 'primitive' painters. Surprisingly, however, he was

not represented in the Karolik Collection of American Painting, 1815–1856, lately exhibited in the USIS Gallery of the American Embassy in London, where Toole would have shone among his contemporaries in that vigorous if barely recorded period between the eminence of Copley and Benjamin West and the later achievement of Eakins, Homer, and Ryder.

What makes this well-printed, illustrated album of some historic interest is the fact that John Toole (born incidentally in Dublin but sent out to Charlottesville, Virginia, as a lad in 1827) is one of the very few American primitive painters whose letters have survived, and from which his life and movements can therefore be reconstructed. His wife bore him six children, so that all his industry in fulfilling often five portrait commissions a week was needed to support the family entirely with the proceeds of his brush. The country's new hunger for knowledge and art was now beginning to encourage the import of drawing books from Europe, and their production also in America; and Toole's rendering of a limb or a gesture was no doubt often derived from these sources. His crayon studies from engravings after Le Brun also served to discipline his hand and eye, gradually removing some of the gaucheries of his early style without loss of that clear-eyed honesty which informs his characterizations. The sturdy and monumental nature of Toole's best work calls to mind such painting as Jefferson Grant's study of two children in pantaloons at Brooklyn in 1843—another illustration of the candour of the American pioneer artist whose self-sufficiency was fortified by continual practice and attention to such instructive exemplars as came his way.

The most considerable and rhetorical of Toole's historical paintings, *The Capture of Major André*, is also a considerable curiosity artistically. This incident, which became a folklore, inspired several other painters at that period to depict imaginatively this British officer's arrest near Tarrytown in 1780 by members of the American militia through the discovery of secret papers tucked in the major's boot. Toole's resourcefulness was evidently taxed to the limit in rendering the entreating gesture of the officer deprived of his boot and his liberty, and the mingled amazement and scorn of the American heroes. What Charles Le Brun and the drawing book professors would have made of this endearingly demonstrative *magnum opus* can only be conjectured. That it is very properly cherished in the Museum of Fine Arts at Charlottesville is certain.

Toole's letters incline to be trivial, however, usually referring to commonplace domesticities and debts, and disappointing us with the intelligence that he failed to hear Jenny Lind as a concert ticket was beyond his means. Even so, the correspondence has been well worth editing to provide the basis of an absorbing study of pioneer art in its harsh environment: in Carl Drepperd's phrase, 'the painted record of America in the process of achieving a *fine art* of its own'.

NEVILE WALLIS

THE WORKSHOP OF THE WORLD: BRITISH ECONOMIC HISTORY FROM 1820 TO 1880. *By J. D. Chambers. London, Oxford University Press*, 1961. 8*s* 6*d net*

Appearing at a time of growing anxiety over Britain's relatively slow rate of economic growth, Professor Chambers' penetrating essay gives us a provocative glimpse into a more buoyant, optimistic age, an age when Britain was veritably the workshop of the world. It has been estimated that between 1820 and 1880, when about 10 per cent of the national income was being invested, the rate of growth of Britain's industrial production was more than 3 per cent per annum, average real incomes were rising appreciably, and the common man was at last belatedly enjoying a share in the fruits of the industrial revolution. The remarkable feature of this episode in economic history is not so much that this was the first transition of a primarily agricultural and commercial economy to a modern industrial state, but that it was the 'product of natural growth and only marginally dependant on outside

sources of capital and skill'. Historians have justifiably complained that the change could have been better managed, that the social cost was too high: in view of the feverish efforts of to-day's underdeveloped economies to achieve sustained economic growth, Professor Chambers rightly emphasizes that the amazing thing is that it was achieved at all. Other nations, soon to rival Britain as manufacturers, were materially assisted by British enterprise, capital and labour. The stage is set for the next period when Britain, the pioneer of the world industrial revolution, had given way to Britain, 'the world's banker, trader and collier', and we catch a sight of developments which are premonitory of the economic difficulties of the present day.

This is a fine book, and perhaps only those who have delved into one or other of the topics which form the eight chapters will fully appreciate the succinct way in which the author marshalls and discusses the relevant facts. The story of the railways is told in ten terse pages; the complicated subjects of population and the growth of towns recounted in twenty; and the coming of the joint-stock company with limited liability, and its social and economic implications, presented in less than eight. However, this compression does have its dangers. The general reader may well be puzzled by some of Professor Chambers' tightly argued descriptions of the mechanisms whereby certain events took place, especially in the chapters on banking and the trade cycle. Nevertheless, technical terminology is avoided wherever possible, and only occasionally is the flow of homely language interrupted by a collection of necessary statistics. Although the majority of the illustrations are well known, others are refreshingly new, and the book is spiced with telling and quotable phrases.

There are faults, of course. There are a few factual mistakes. Some may quarrel with the relative importance accorded to some of the themes and with certain of the author's interpretations. More might have been said of the development of specific industries. As usual in general economic histories, Scotland once again masquerades as a country possessing a sensible banking system, the City of Glasgow, clever engineers, good ideas, and very little else. The index is inadequate, and there are far too many trifling errors in the citations. Books and articles are all too frequently retitled, authors' names wrongly spelt or accorded erroneous initials, and dates of publications mistimed. For example, Robert Trow-Smith's *History of British Livestock Husbandry, 1700–1900* appears as *The English Livestock Husbandry, 1700–1800*, and in the subterranean world of footnotes and in the bibliography Mr. A. E. Musson lurks under three aliases. Minor imperfections, but irritating none the less.

Despite these weaknesses, many of which could have been eradicated by thorough proof reading, this inexpensive, stimulating little book should be a great success. It certainly deserves to be.

PETER L. PAYNE

LIBRARY ADDITIONS

Fellows and Associates are reminded that they may borrow up to five books at a time from the Library and retain them for a month. Members living outside London may borrow books by post. Books sent by post are despatched at the cost of the Society and returned at the cost of the borrower. Books marked with an asterisk are part of the reference library, and not normally available for loan.

FINE ARTS

BINYON, ROBERT LAURENCE, *and* SEXTON, JOHN JOSEPH O'BRIEN—Japanese colour prints: edited by Basil Gray. New edition. *London, Faber*, 1960.

BONYTHON, KYM—Modern Australian painting and sculpture; a survey of Australian art from 1950 to 1960. *Adelaide, K. Bonython*, 1960.

BROWSE, LILLIAN—Sickert. *London, Hart-Davis*, 1960.

CHIESA, ANGELA OTTINO DELLA—Botticelli and his contemporaries. *London, Batsford*, 1960.

DYER, WILLIAM GARFIELD SIMMONS—Joshua Cristall: Cornish painter, President of the Society of Painters in Watercolours (Royal Society of Painters in Watercolours): an essay awarded the Silver Medal of the Royal Cornwall Polytechnic Society in the Sir Edward Nicholl Prize Essay Competition, 1958, together with a comprehensive catalogue of the works of Joshua Cristall in national, public and private galleries and collections in the United Kingdom and Northern Ireland. *Polytechnic Hall, Falmouth (Cornwall), Royal Cornwall Polytechnic Society*, 1959.

GERSON, HORST *and* KUILE, ENGLEBERT HENDRIK ter—Art and architecture in Belgium, 1600 to 1800; translated from the Dutch by Olive Renier. *Harmondsworth, Penguin Books*, 1960. (*Pelican history of art, edited by Nikolaus Pevsner—No.* Z18.)

GOMBRICH, ERNST HANS—Art and illusion: a study in the psychology of pictorial representation. *London, Phaidon Press; New York, Pantheon Book*, 1960. (*Mellon lectures in the fine arts*—1956.)

HENDY, *Sir* PHILIP—The National Gallery, London. *London, Thames & Hudson*, 1960. (*World of art series.*)

KATZENELLENBOGEN, ADOLF—The sculptural programs of Chartres cathedral: Christ, Mary, Ecclesia. *Baltimore (Md.), Johns Hopkins Press; London, Oxford University Press*, 1959.

SCHODER, RAYMOND V.—Masterpieces of Greek art: text and colour photography by Raymond V. Schoder. *London, Studio*, 1960.

SUTTON, DENYS—Bonnard (1867-1947); with an introduction and notes by Denys Sutton. *London, Faber*, 1957. (*Faber gallery, edited by R. H. Wilenski.*)

WATERHOUSE, ELLIS KIRKHAM—Gainsborough, by Ellis Waterhouse. *London, Hulton*, 1958.

WILDENSTEIN, GEORGES—The paintings of Fragonard; translated from the French by C. W. Chilton (introductory text) and Mrs. A. L. Kitson (catalogue). Complete edition. *London, Phaidon*, 1960.

LITERATURE AND AUTHORSHIP

DEFOE, DANIEL—The Works of Daniel Defoe, with a memoir of his life and writings by William Hazlitt. 3 Vols. *London, John Clements*, 1840-41. Presented by F. Bellinger.

HISTORY AND TOPOGRAPHY

BLAKE, GEORGE—Lloyd's register of shipping, 1760-1960; illustrated by David Knight. *London, Lloyd's*, 1960.

DE BEER, *Sir* GAVIN (*editor*)—The sciences were never at war. *London, Nelson*, 1960. 'The transcription of portions of the manuscript correspondence of Sir Hans Sloane, René-Antoine de Réamur, Sir Joseph Banks, and other men of science.'

DERRY, THOMAS KINGSTON, *and* WILLIAMS, TREVOR ILLTYD—A short history of technology from the earliest times to A.D. 1900. *Oxford, Clarendon Press*, 1960. Presented by the authors.

FITTON, ROBERT SUCKSMITH, *and* WADSWORTH, A. P.—The Strutts and the Arkwrights, 1758-1830: a study of the early factory system. *Manchester, Manchester University Press*, 1959.

GIBBS-SMITH, CHARLES HARVARD—The aeroplane: an historical survey of its origins and development. *London, H.M.S.O.*, 1960. (*London, Science Museum, Publications.*)

FROM THE JOURNAL OF 1861

VOLUME IX. *20th September*

RAILWAY COLLISIONS

[*Two major accidents had occurred within seven days. On 25th August,* 1861, 23 *people were killed and* 175 *injured in a collision in the Clayton tunnel* (*London–Brighton Line*); *on 2nd September,* 16 *died and* 320 *were injured as the result of an accident at Kentish Town* (*Hampstead Junction*).]

SIR,—The late dreadful railway slaughters have set all who are exposed to like dangers thinking how they may best be diminished. As I have to spend much of my time on railways, whatever can make them safer is to me a matter of personal as well as of general interest.

Much has been done to diminish the chance of collision, but not all that is needed, as recent examples show. Years ago it was proposed that clocks should be used with two fingers, one to be moved by the clockwork, the other to be set to the time at which the last train passed, by a lever, to be moved by the train as it passed. Of course, the distance between the two fingers would show the interval of time elapsed since the fixed finger was set, and the driver of the next train would know pretty nearly how much the preceding train was ahead. The objections to this plan are obviously, first, the cost of procuring as many clocks as would be needed; secondly, the trouble and expense of keeping them all wound up and in order. The advantages might, however, be secured by very simple and cheap means. It would be very easy and inexpensive to erect at short intervals along the line danger signals, to be raised by a lever acted upon by each passing train, and allowed to descend slowly and gradually, the descent being regulated by a fly or other simple regulator. Such a danger signal, if quite up, would inform a driver that the train had just passed, and that he must stop instanter. If partly up, he would know whether 1, 2, 3 or more minutes had elapsed, and would cut off steam more or less accordingly. If the signal was quite down, he would know that no train had passed, at the least, during the time necessary for the signal to descend, and he might proceed with confidence.

If such signals were used at sufficiently short intervals, there would be little risk of one train overtaking another unawares.

If railway companies would compel their managers, station masters, and all other servants concerned in any accident, to pay a part of the loss occasioned by them, accidents would be less frequent. Of course, if those employed had to bear this extra risk, they would require larger remuneration, which would be a cause of profit to the careful but of loss to the careless. The extra remuneration would be money well laid out. It is stated in to-day's *Times*, that last year the railway companies paid in compensation for accidents and losses £181,170. Much of that large sum might have been saved were part of the risk thrown upon the managers, &c., and they [were] paid to incur that risk, getting profit in proportion to their success in avoiding it. The real loss from accidents is far greater than the compensation paid, for carriages and engines are broken, and to some extent travelling discouraged. To increase risk by saving, is extravagant economy.

I am, &c.,

P. H. HOLLAND

36, *Cavendish-square*